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STUDIES ON TREE ROOT ACTIVITIES

Part I. An Apparatus for Studying Root Respiration and Factors which Influence It.*

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The activities of fruit tree roots present many problems for the horticulturist, very few of which have been carefully investigated, primarily because of lack of suitable methods of observation, especially under controlled conditions.

The writer (*5*) previously made observations in the field on roots of mature apple and filbert trees, and also on one-year-old nursery stock (apple trees) in culture solutions. With these two species primary growth in length of roots took place irrespective of the time of the year and of the time when top growth was being made. Certain external conditions such as temperature, drought, submergence and poor aeration, produced different responses in their root activity. Consequently, it was thought desirable to ascertain how great were the inherent differences in metabolism of different species under similar controlled conditions and also to determine how closely the activities of root and top were related. A measurement of one of the most obvious manifestations of metabolism, namely respiration, at once suggested itself.

No previous work could be found giving a description of an apparatus suitable for measuring the respiration of tree roots although descriptions of several types were recorded for herbaceous plants including grains (*3, 4, 7, 8, 10, 11*), etc. The majority of the types of apparatus used are in principle similar to that of Pettinkofer (*10*), although greatly modified. By means of a suction pump or aspirator, air is supplied which, before passing through the plant chamber, is freed from CO_2 by strong alkali solutions or soda lime towers. After passing through the plant chamber the air is passed through variously devised towers or bottles containing a standard alkali in which the CO_2 produced is absorbed. Practically all the experiments have been made for short time periods only and for intermittent rather than continuous CO_2 determination.

Parker (*10*) grew cowpeas, buckwheat, sorgham and soybeans in aspirated soil cultures which, from seven days after they were planted until maturity, were sealed in the one-gallon glazed earthenware vessels used. He made determinations of the CO_2 produced by the roots daily during the entire period. The aspiration stopped at night however. Newton (*9*) grew vetch and peas in sand cultures in one-quart Mason jars, and when the plants were

*Apparatus used and described as part of a Thesis submitted in partial requirement for the Ph.D. degree at the University of California, October, 1928.

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about fifty days old measured the CO_2 evolved from the roots. Milad (7) grew vetch in culture solutions and found that with similar plants of the same age and approximately the same weight as those used by Newton the CO_2 output of the roots from his plants was much greater than the figure recorded by Newton. He points out that there is considerable opportunity in sand for the CO_2 to collect in channels and not be completely displaced, and attributes Newton's lower figures to this cause.

As all the apparatuses hitherto used were small and were devised for short-time experiments in which short-lived plants were used, they are not suitable for similar experiments with trees. In trees the large size of the root, the secondary growth due to the activity of the cambium, the presence of stored food and the fact that primary root growth in length takes place throughout the year, are all factors which it was not necessary to take into account in the experiments of the previous workers. Consequently, for an experiment on tree root respiration an apparatus of larger size than any previously used is necessary. Moreover, the experiment must necessarily be carried out for a long period of time and, in order to obtain significant results, the apparatus used must be operated continuously so that there will be no possibility of missing the effect of any of the numerous changes likely to occur during the various phases of growth.

The main problem, therefore, presented itself as one of a pioneering nature, namely:

1. To devise an apparatus suitable for measuring respiration of tree roots, and one that will work on a large scale.
2. Having devised the apparatus, to grow trees successfully in it under conditions necessarily imposed on them by the apparatus.

Description of the Apparatus, Materials and Methods

Respiration of the roots was measured by the CO_2 they excreted. Solutions were used as a nutrient medium instead of sand because, as already pointed out, there is considerable discrepancy in the results of Milad (7) and Newton (9). The explanation offered by Milad as to why complete displacement of CO_2 from sand is more difficult than in solutions seems reasonable, and the difficulty of good displacement of CO_2 would be much greater with large containers.

The accompanying diagram (Fig. 1.) and Plates I and II show in its complete form the apparatus used.

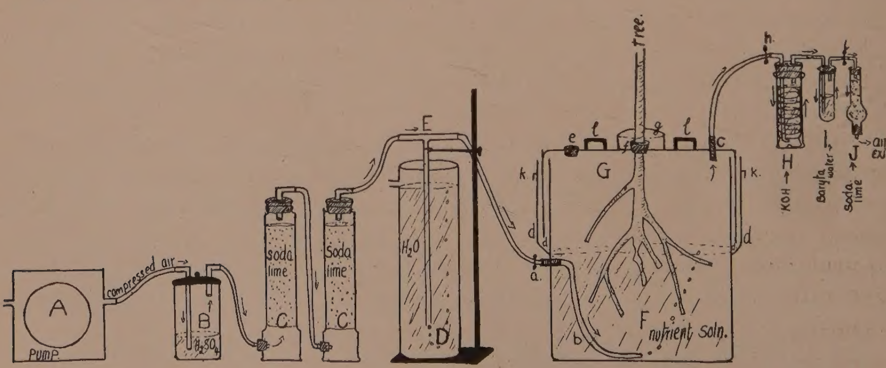

Figure 1. Apparatus used. (For explanation see text.)

Air under pressure was pumped from the pump A through the jar B containing H_2SO_4 to dry the air and then through the soda lime towers C to take out any CO_2 it might contain. D is a tank containing water, maintained at a constant level, into which is inserted the T tube E, open at the lower end. By this device the air was maintained at any desired pressure by raising or lowering E, provided sufficient air was turned on at the pump to have a small quantity escape through the open end. The dry CO_2 free air passed from tube E into the container F at (a) and through a glass tube (b) into the nutrient solution where, besides aerating the solution, it displaced and carried with it the CO_2 produced by the roots out through the tube (c) into the Milligan absorbing bottle H containing KOH (or NaOH). The KOH absorbed the CO_2 and, in order to ensure that no CO_2 was escaping, the air passed from H to a tube I containing Baryta water which in turn was connected to a small tube of soda lime J to prevent any CO_2 from the atmosphere entering the Baryta water.

To ensure that the container F was air tight it was made with a double collar around the top (d) into which the lid G fitted. This was filled with water for a seal. The tree was inserted through the cork (f) and around (f) was another collar (g). The tree was sealed in the cork with grafting wax and the collar (g) was filled with water to keep the wax from becoming soft and also to detect any leakage. The wax proved very satisfactory. The lid G was wired down to projections (k) on the sides of the container and could be raised by means of handles at (1). (e) is an opening to add solution if required without raising the lid. At (a), (h) and (i) were stop cocks. (a) and (h) were shut off when the absorbing bottle H was being changed to avoid loss of CO_2 during the process. The rate of bubbling air through the system was regulated at (i).

The apparatus was set up and the trees put in place on April 3, 1927. and it was operated continuously until July 21, 1928. Twenty-five trees on eight different kinds of root stocks, listed later, were used.

The 25 galvanized iron containers in which the trees were grown each had a capacity of 60 litres. They were painted inside with asphalt paint, and set up in a series of three frames (Plate I).

Hoagland's nutrient solution, containing KNO_3, $MgSO_4$, $Ca(NO_3)_2 4H_2O$ and KH_2PO_4 in the following concentration expressed as parts per million, was used: K 190, Ca 172, Mg 52, NO_3 700, PO_4 117, SO_4 200. Ferric tartrate or citrate, 0.5 per cent solution, was added when required, as a source of iron. The solutions were kept only approximately up to the original concentration, although care was taken to see that none of the nutrients became excessively depleted. A fairly close check was kept on the NO_3 ion by means of the diphenolamine reagent test which can be used quantitatively with a fair degree of accuracy by making suitable dilutions. 1 to 5 p.p.m. NO_3 gives a pale blue colour whereas a strong blue colour is produced almost immediately by 25 p.p.m. (*6*). Tests for other ions present were made from time to time using Hibbard's method (*6*) for rapid quantitative estimations.

During the early part of the experiment the solutions were completely changed and the containers scrubbed out at frequent intervals. While this

process was going on, the tree was removed to another container filled with tap water. The effect of this treatment on root respiration was so pronounced that it was discontinued and for the most part new solution was merely added with the trees in place.

Thirty litres of nutrient solution were originally used in the containers but on June 11, 1927 this was increased to forty litres.

The absorbing solutions were replaced at least weekly and usually several times a week if CO_2 was being produced rapidly. From 1 to 3 per cent solutions of KOH (or NaOH) were found to be most convenient and satisfactory, depending on the rate of production of CO_2. 150 c.c. of solution were used in the absorbing bottles and 10 c.c. aliquots titrated according to the method of Blasdale (*4*), by precipitating the carbonate first with $BaCl_2$ and then titrating the excess NaOH with $\frac{N}{10}$ H_2SO_4, using phenolphthalein as an indicator. The rate of the air bubbling through the absorption bottles was adjusted so that it was approximately the same in each bottle. In order to determine how effectively or uniformly the CO_2 was being displaced, samples of the atmosphere above the solution in the container were taken at different times and the percentage composition of O_2 and CO_2 measured by means of an Orsat apparatus. The following determinations will suffice to show that displacement was quite effective and that there was little tendency for CO_2 to accumulate in the containers:

Date	Container No.	Grms. CO_2 excreted by root 168 hrs.	% CO_2	% O_2
Sept. 3, 1927	1	1.45	2.0	16.6
	4	4.63	2.6	16.0
	9	3.90	2.4	16.0
	15	1.04	2.0	16.5
	19	0.43	1.5	17.0
	22	1.54	2.0	16.6
	25	3.50	2.5	16.2
March 7, 1928	1	1.66	2.2	16.6
	7	1.98	2.2	16.5
	16	0.78	1.8	17.0
	21	0.31	2.0	16.5
	24	0.76	2.0	16.1

Average of 4 sets of determinations at different periods:

Container No.	Grms. CO_2 excreted by root 168 hrs.	% CO_2	% O_2
1	1.63	2.0	16.3
4	3.27	2.6	16.0
9	2.88	2.5	16.1
19	1.41	2.0	16.4
22	2.36	2.4	16.2
25	3.18	2.5	16.1

To determine how much of the CO_2 produced was due to organisms or any cause other than root respiration, containers Nos. 10 and 11, the original trees in which died and to which reference will be made later, were used. The tree in No. 10 was taken out on July 2, 1927 and the container filled with a fresh solution, sealed and connected to an absorption bottle and allowed to run for six weeks. At the end of this time 0.10 grms. of CO_2 were recorded. The tree in No. 11 was left in the container undisturbed and the CO_2 produced measured weekly until November 26, 1927. Furthermore, towards the conclusion of the experiment after a number of the trees were taken out, their containers were sealed and determinations made using the solutions from which the trees had been removed.

The following results were recorded:

Container No.	Grms. CO_2 168 hrs.	Container No.	Grms. CO_2 168 hrs.
5	0.05	19	0.05
15	0.08	20	0.07
18	0.06	22	0.03

These results showed that any source of CO_2 production other than root respiration was negligible for purposes of the experiment.

In order to maintain the temperature of the nutrient solution as uniform as possible the containers were packed around the sides with sphagnum moss. A cushion was also made, filled with moss, to place over the tops of the containers (Plate II). The moss was kept moist at all times. By this means the temperature of the nutrient solution was kept uniformly around 15°C. except between January 14 and February 16, 1928, when the heat was shut off in the greenhouse and lower temperatures maintained in an attempt to bring the trees through the rest period. During this time the solution in the containers varied from 5° to 14°C.

The following trees were originally used:

Apricot on Myrobalan root	3 trees	Nos. 1, 2, 3,
Apricot on Apricot root	3 "	" 4, 5, 6,
Bing Cherry on Mazzard root	3 "	" 7, 8, 9,
Almond (Non-pareil) on Almond root	2 "	" 10, 11,
Elberta Peach on Peach root	3 "	" 12, 13, 14,
Delicious Apple on Delicious root	3 "	" 16, 17, 18,
Bartlett Pear on French Seedling root	3 "	" 19, 20, 21,
Hardy Pear on Quince root	3 "	" 22, 23, 24,
Bartlett Pear on Japanese Seedling	2 "	" 25 and 26.

The Almond trees Nos. 10 and 11, and the Peach trees Nos. 12, 13 and 14 died during the course of the experiment, so two of the containers were used for apple trees No. 15 and 31 on July 16, 1927 and April 7, 1928, respectively. The remaining three containers, together with a fourth from which apple tree No. 17 was removed on April 7, 1928, were used for two new Bartlett pear trees on French roots (Nos. 27 and 28) and two new Apricot trees on Myrobalan roots (Nos. 29 and 30).

The trees were all obtained from local nurseries with no previous knowledge of their history other than that they were what are sold as one-year-old stock, which would mean that the roots were two years old.

On setting the trees in the containers all branches and laterals were removed from the tops leaving only the main stem (Pl. XIIa). All small roots and fibres, which for purposes of the discussion will hereafter be referred to as fibres, were removed from the root, leaving only the root-stem and main branches, which will be referred to as the root stub (Pl. XIIa).

History and General Behavior of the Trees

During 1927 the apricot on apricot trees Nos. 4, 5 and 6, Bing on Mazzard Nos. 7, 8 and 9, pear on quince Nos. 22, 23 and 24, and pear on Jap

Nos. 25 and 26 made excellent growth comparable to that of trees of the same age out in the field. These trees were considered as normal trees—Group I.

The apricot on Myrobalan trees Nos. 1, 2 and 3, apple on apple Nos. 15, 16, 17 and 18, pear on French Nos. 19, 20 and 21, especially during the earlier part of 1927 did not do well for the reasons given below, and were considered as starved trees—Group II.

The apricot on Myrobalan when they were initially placed in the containers did not have their roots immersed in the solution. Anderson (*1*), growing young Bartlett on French trees in solutions, found it was not necessary actually to submerge the roots in the solution for good root growth to ensue, but that the saturated atmosphere above the solution would suffice until the new roots grew down into the solution. Consequently, as the roots were somewhat short after pruning off the broken ends, they were suspended in the container with the ends of the roots above the solution. New roots and shoots started to grow readily but the roots died back from the tips before reaching the nutrient medium and the new shoots were very weak, presumably from lack of water. When the level of the solution was raised on June 7 and all the roots immersed, new roots were formed very shortly afterwards and normal shoot and top growth took place.

The apple trees used in 1927, Nos. 16, 17 and 18, were rather poor trees to use for the experiment but were the only ones available at the time. A considerable amount of new root and shoot growth had taken place before they were placed in the containers. This new growth had necessarily to be trimmed off for purposes of the experiment and undoubtedly this greatly lowered the vitality of the trees. They started off making root and shoot growth but lacked vigor. On July 9th they were all sunk well into the solution and disconnected from the air line of the apparatus, and a very vigorous stream of air from another pump was passed through the solutions until September 10th, on which date they were again connected to the apparatus. This vigorous aeration seemed to revive them considerably and renewed root and shoot growth followed. It has been shown that the CO_2 in any of the containers never reached an unfavorable concentration for growth, so possibly the rate of aeration had an influence on the renewed growth.

The pear on French trees, Nos. 19, 20 and 21, initially started out well but from June 10th until August 13, 1927, distilled water was substituted for Hoagland's solution in their containers. This distilled water killed the new roots, and as a result, shoot growth soon afterwards stopped and remained at a standstill in an unhealthy and weakened condition. That the trees here placed in Group II can be grown successfully was demonstrated by the normal behavior after the roots were wholly immersed in the solution and the excellent growth of the new trees used in 1928 (Pl. XII to Pl. XV). The almond trees, Nos. 10 and 11 and peach trees Nos. 12, 13 and 14 were failures. As in the case of the apricot on Myrobalan, their roots were not initially immersed in the solution. New root and shoot growth started but very soon afterwards died. On June 11th, when the roots were

immersed, no recovery was made and moreover, they became heavily infected with a fungus. The peach trees were given the vigorous aeration treatment similar to that given to the apples. It was interesting to note that despite the dead tops, the root made very rapid growth in length during this treatment. No second attempt was made to grow either almonds or peaches.

The apparatus has been used for certain studies in tree root activities developed along the lines suggested at the beginning of this paper. The results of these studies will be presented in future papers.

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LEGENDS FOR PLATES

Plate I. Containers set in frames.

Plate II. The complete "set-up".

Plate III. Apricot on Myrobalan Tree No. 2, February 2, 1928. "Root growth was rapid during December and January."

Plate IV. Apricot on Apricot Tree No. 5, February 2, 1928. "Slight amount of new root growth took place from December 31 to February 25, 1928."

Plate V. Bing Cherry on Mazzard Tree No. 9, February 2, 1928. "Shows heavy new root growth during winter."

Plate VI. Delicious Apple on Delicious Tree No. 15, February 2, 1928. "During January and February rapid root growth took place. These new roots were of a long and stringy nature with practically no side shoots."

Plate VII. Bartlett Pear on French Tree No. 10, February 2, 1928. "During December 1927, and January and February 1928, new root growth was very rapid."

Plate VIII. Hardy Pear on Quince Tree No. 23, February 2, 1928. "New roots which were very much branched grew during December, January and February."

Plate IX. Bartlett Pear on Jap Tree No. 25, February 2, 1928. "Winter root growth not heavy. Note dense mat at collar."

(NOTE: As stated in text on setting up only a stub was left, e.g. Plates XIIa—XVa so all root growth shown was made during one season. New rapidly growing roots appear as white threads.)

Plate X. Apricot on Apricot Tree No. 4, July 21, 1928. "Dense root, shallow type." Root small compared to top. (Note 5′ tape measure on right.)

Plate XI. Bartlett Pear on Jap Tree No. 25, July 21, 1928. "Relative to size of top, root growth very small." (Note 5′ tape measure on right.)

(The tops of these trees had been severely pruned in 1928 prior to July 21.)

NEW TREES

Plate XIIa. Delicious Apple on Delicious Tree No. 31 as placed in container April 7, 1928.

Plate XII. Delicious Apple on Delicious Tree No. 31 showing growth made up to July 21, 1928. (Note 5′ tape on right.)

Plate XIIIa. Bartlett Pear on French Tree No. 27 as placed in container April 7 1928.

Plate XIII. Bartlett Pear on French Tree No. 27 showing growth made up to July 21, 1928. (Note 5′ tape measure on right.)

NEW TREES

Plate XIVa. Bartlett Pear on French Tree No. 28 as set in container April 7 1928.

Plate XIV. Bartlett Pear on French Tree No. 28 showing growth made up to July 21, 1928. (Note 5′ tape measure.)

Plate XVa. Apricot on Myrobalan Trees No. 29 (upper) and No. 30 (lower) as placed in container April 11, 1928.

Plate XV. Apricot on Myrobalan Trees No. 29 (left) and No. 30 (right) showing growth made up to July 21, 1928. (Note 5′ tape measure.)

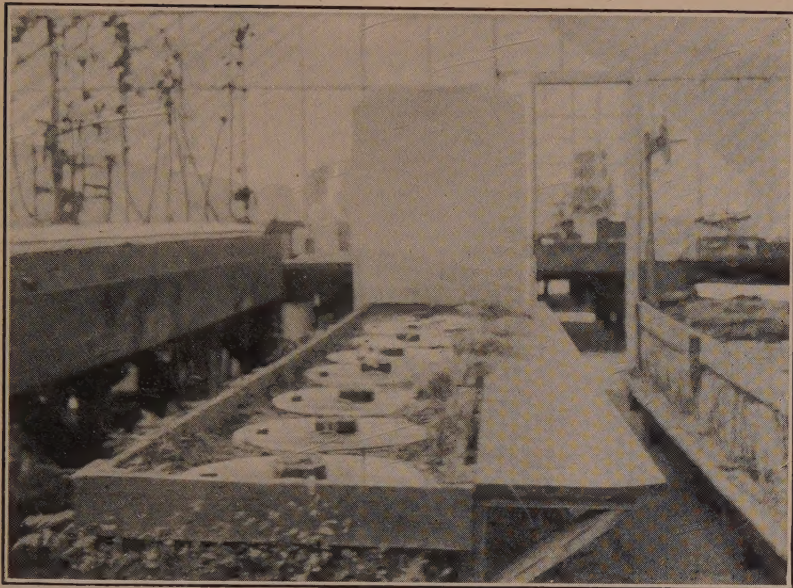

FIGURE 1.

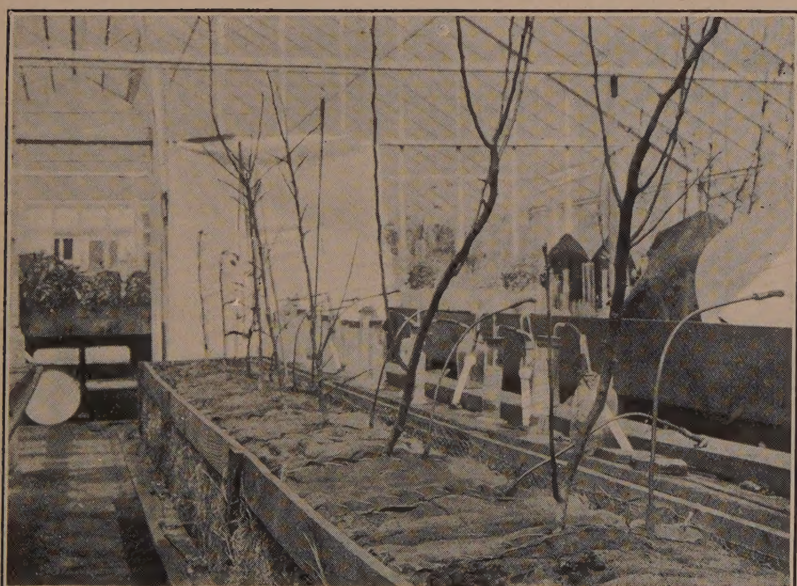

PLATE II.

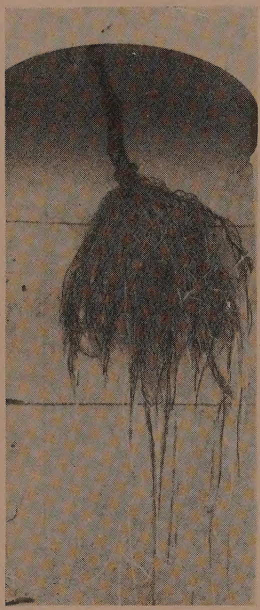

PLATE III.

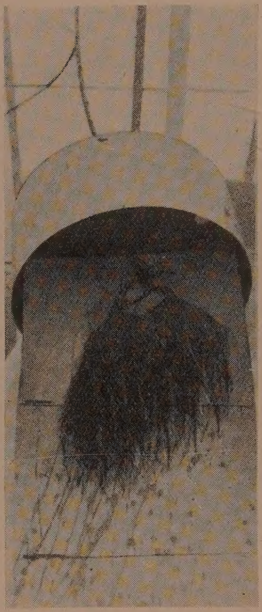

PLATE IV.

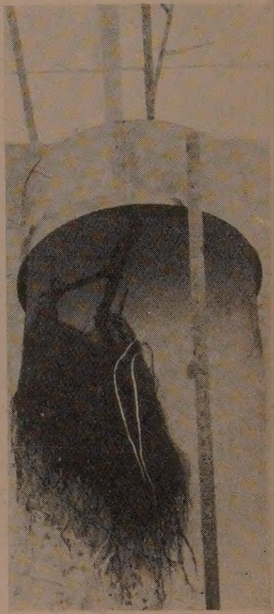

PLATE V.

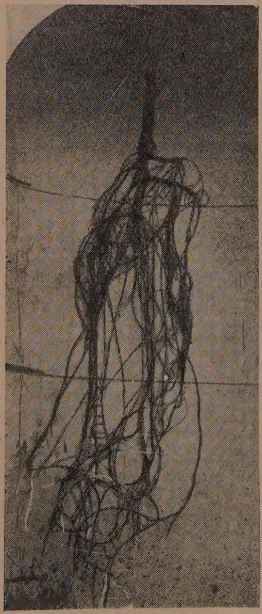

PLATE VI.

PLATE VII.

PLATE VIII.

Plate IX.

Plate X.

Plate XI.

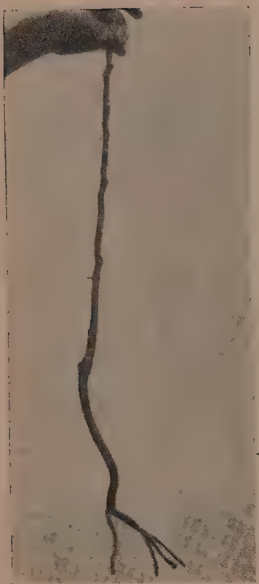

Plate XIIa.

Plate XII.

Plate XIIIa.

Plate XIII.

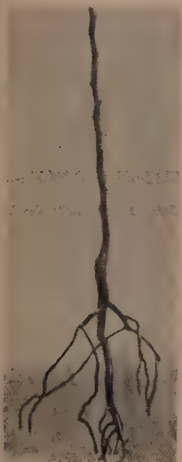

PLATE XIVa.

PLATE XIV.

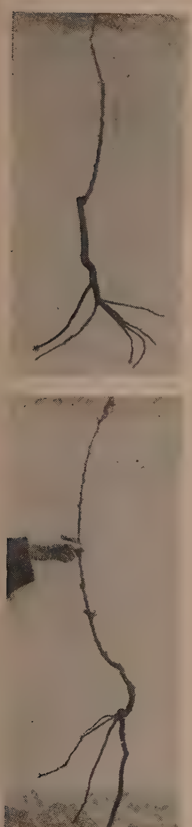

PLATE XVa.

PLATE XV.

THE EFFECT OF CUTTING GARNET WHEAT AT DIFFERENT STAGES OF MATURITY AND ON CONSECUTIVE DATES AFTER THE OCCURRENCE OF FROST*†

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Frost damage is the greatest menace to wheat production in districts where early fall frosts occur. Experience has shown that, due to the protection offered by larger mass, grain in the sheaf or stock is damaged much less by frost than standing grain of the same degree of immaturity. If the cut grain has a day or so to dry out before frost occurs, it has an additional advantage in escaping frost damage. Wheat growers living in the Park Belt of central Alberta, where wheat tends to produce a relatively high percentage of piebald kernels in wet seasons, believe that, in addition to avoiding frost damage, they get a smaller percentage of piebald kernels, and thus a sample that will take a higher commercial grade, if the wheat is cut before the crop is fully mature. The importance of early cutting is also realized by large growers who wish to harvest large acreages with a minimum outlay for harvest machinery, and who desire to start harvesting operations as early as possible so that the last of the crop harvested will not be over-ripe and result in losses from shattering. A very vital question which presents itself under such conditions is "how immature can wheat be cut without serious financial loss?"

The question of when to start harvesting operations is rendered more complicated by the introduction of new varieties. Research and practice indicate fairly clearly how soon many of the older varieties of wheat can be cut without serious losses of yield and grade. It is not known, however, whether Garnet will react to cutting before the grain is fully matured in the same way as Marquis and some of the older sorts. This study was designed to give information on the point in question but the occurrence of frost on August 23 and 27, while the grain was in the medium dough stage, prevented the completion of the project as originally planned, but provided most interesting information relative to the reaction of immature Garnet wheat in particular, and immature wheat in general, to frost damage.

Method of Experiment

The data reported in this article were secured during the crop season of 1928. A pure line of Garnet wheat was seeded on May 18 as a regular field crop and was harvested as outlined.

*This investigation was conducted at the Dominion Experimental Station, Lacombe, with the approval of F. H. Reed, Superintendent of the Station. The author is indebted to Dr. F. T. Shutt, Dominion Chemist, Central Experimental Farm, Ottawa, for the chemical analysis of the samples of the threshed grain from the different dates of cutting.

‡Assistant Superintendent.

†Read at the annual meeting of the Western Canadian Society of Agronomy, Saskatoon, Sask., December, 1928.

In an endeavor to eliminate error due to differences in maturity as much as possible, one thousand average sized heads in the same stage of development, as indicated by the appearance of at least one anther, were marked on the same day, July 28. The marking was done by slipping the loop of a small tag over the head. This loop slipped down to the upper leaf and, being quite loose, did not interfere with the development of the plant in any way; the small white tags about ⅜ of an inch in circumference assisted materially in identifying the selected heads when harvesting on the different dates of cutting.

It was planned to gather 100 different heads on ten different occasions at two day intervals beginning at the milk stage. As a result of cool weather during August, the ripening season was longer than anticipated and the ten different cuttings were not sufficient to cover the full ripening period; hence extra cuttings of untagged heads had to be made. There is a certain amount of unavoidable error resulting from the inclusion of a number of cuttings of untagged heads in the study; on the other hand, the range of the flowering period covered three days only, hence the report of the last nine cuttings, while subject to some error, is still of sufficient accuracy to be of considerable practical value.

In harvesting, the full length of the straw without the root was left intact and attached to the heads. The heads with attached straw of each cutting were tied into a loose sheaf, tagged, and hung in the shade in an unheated and well ventilated room until all the samples had been collected and had cured sufficiently to thresh. The idea throughout was to duplicate, as nearly as possible, field conditions where the grain is cut with the binder and stooked immediately. Each cutting was carefully threshed by having the heads removed from the straw, wrapped in a cloth and rubbed out by hand, thus eliminating as much as possible the loss of any kernels in threshing. The different data recorded are presented in the accompanying table.

Weight Per Thousand Kernels

The weight per thousand kernels was taken as a factor to indicate the gain or loss in weight of the total material which goes to make up a kernel. Differences between this value for different cuttings would therefore indicate a gain or loss as the case may be.

It will be observed that there was a gain in weight as the crop progressed toward maturity from the late milk stage on August 9 to the medium dough stage on August 21. This gain in weight was very rapid between the first and third cutting and appeared to become less rapid as the crop attained greater maturity. This is in agreement with the findings of Thatcher (*16*) and of Saunders as reported by Shutt (*14*) who found a constant increase in weight of kernel from the earliest date of cutting until the last date of collection, when the crop was presumably ripe.

Ary and Sun (*1*) in summarizing investigations on the transference of nutrients from one part of the plant to the other, show that plants, up to the time of flowering, take up mineral nutrients faster than they are laid down.

The effect of cutting Garnet wheat at different stages of maturity and on consecutive dates after the occurrence of frost.

Date of cutting	Stage of maturity	Weight of 1000 kernels (grams)	Moisture	Dry Matter Basis		Grade	Relative yield in per cent	Price per bushel at local elevator ($)	Value per acre ($)
				Protein N. x 5.7 (p. c.)	Ash (p. c.)				
Aug. 9, 1928	Late milk	14.78	10.69	14.01	2.06	Feed	54.1	.48	7.79
" 11, 1928	Late milk to early dough	17.46	10.73	13.87	1.78	Feed	63.9	.48	9.20
" 13, 1928	Early dough	21.01	11.08	13.77	1.65	No. 6	76.9	.55	12.69
" 15, 1928	Early dough	22.11	10.61	13.73	1.71	No. 5	81.0	.67	16.28
" 17, 1928	Soft dough	25.02	10.40	13.76	1.59	No. 4	91.6	.79	21.71
" 19, 1928	Soft dough	26.07	11.01	13.30	1.44	3 Nor.	95.5	.89	25.50
" 21, 1928	Soft to medium dough	27.31	11.07	13.78	1.51	2 Nor.	100.0	.95	28.50
" 23, 1928*	Medium dough	27.27	11.40	13.68	1.43	No. 4	99.9	.79	23.68
" 25, 1928	Medium dough	24.21	10.72	13.61	1.52	No. 5	88.6	.67	17.81
" 27, 1928*	Medium dough	26.56	11.02	13.51	1.46	No. 6	97.3	.55	16.05
" 29, 1928	Medium dough	23.63	11.15	13.57	1.52	Feed	86.5	.48	12.46
" 31, 1928	Firm dough	23.64	11.15	13.48	1.45	Feed	86.5	.48	12.46
Sept. 2, 1928	Firm dough	23.86	10.61	13.43	1.49	Feed	87.4	.48	12.58
" 4, 1928	Firm dough	24.80	10.20	13.43	1.54	Feed	90.8	.48	13.07
" 6, 1928	Firm dough	25.68	10.09	13.65	1.42	Feed	94.0	.48	13.54
" 8, 1928	Firm dough	24.00	10.43	13.35	1.41	Feed	87.9	.48	12.56
" 10, 1928	Firm dough	22.87	10.03	13.44	1.52	Feed	83.7	.48	12.05
" 12, 1928	Firm dough	23.75	10.42	13.52	1.51	Feed	87.0	.48	12.53
" 14, 1928	Firm dough	21.37	9.90	13.35	1.55	Feed	78.2	.48	11.26

* Dates on which crop was frosted.

These materials are elaborated and stored temporarily mainly in the leaves and stems from whence considerable amounts are moved to the grain during the filling period. Saunders (*10*) concludes that the ripening process involves the deposition of proteins, carbohydrates and other materials in the kernel with drying out as the final stage. Ellis (*6*), Stoa (*15*) and Harrington (*7*) found that the translocation of material stored in the leaves and stems to the kernel was seriously interrupted by rust but that it still continued, and concluded that rusted wheat should be left uncut until the normal harvesting stage of maturity was reached before cutting. The evidence as to whether there is a continuance of this translocation of material after cutting is somewhat conflicting and shows that at best there is but a minor movement of this material.

The question which now arises is whether or not this movement of material from the stem and leaves to the kernel continues after the crop is frosted. The normal development of the crop included in this study was interrupted by the occurrence of three degrees of frost during the night of August 22-23, followed by another three degrees during the night of August 26-27. Had frost not affected the normal development of the plant the probable weight of the 1000 kernels of the eighth cutting would have been over 28 grams. A further study of the data indicates that frost injury not only checks any translocation of material but may actually dissipate some of the material already stored, as the weight per thousand kernels had decreased 3.10 grams by the third day following the first occurrence of frost. The alternative explanation for the decrease in the weight per thousand kernels following frost damage would seem to be that the translocation of material from the stems and leaves to the kernel of immature grain continued after cutting unfrosted grain and that there was no further movement of this material after the occurrence of frost. If we accept this theory, the lowering of the dry matter content of the kernels by frost damage is not disproven, as we find the weight per thousand kernels continues to decrease from day to day after the sample was damaged, but indicates that the extent of the dissipation of the dry matter of the kernel by frost damage is not as great as indicated by the first theory.

Johnson and Whitcomb (8) state that wheat which has been affected by a killing frost should be harvested as soon as possible in order to obtain the highest yield and weight per bushel. This recommendation is in agreement with the data presented in tabular form which indicate that the sooner wheat is harvested after being frosted the greater the yield will be. This point is illustrated more emphatically by factors discussed under separate headings.

Protein

At the present time the protein content of wheat is used as an index to the quality of the wheat with respect to its milling value. It will be seen in the accompanying table that there is no consistent gain or loss of protein content from one cutting to another, although there appears to be a slight tendency for the percentage protein content to decrease from the first to the fourth cutting. Shutt (*13, 14*) found that during the first few days of

filling the deposition of other material was relatively more rapid than that of protein, but increased during the period of greatest physiological activity. Brenchley and Hall (*4*) harvested wheat at three day intervals from just after flowering until ripe. The nitrogen content of the dry matter decreased rapidly at first but showed some indication of an increase as maturity is reached.

The lack of a definite and consistent variation in percentages of protein resulting from different dates of cutting of this investigation is in agreement with the work of Mangels and Stoa (*9*), who found no consistent variation of protein content at different stages of maturity for the four seasons of 1924-1927 inclusive. Their work showed that differences of temperature and rainfall accounted to some extent for the lack of consistency in protein content variation for different stages of maturity.

Shutt (*13*) found that the grams of protein increased throughout the whole period of filling and ripening, "at first very rapidly, subsequently and during the later stages of the ripening process, more slowly". In making this determination the formula used was

$$\frac{(\text{per cent protein x weight of 1,000 kernels})}{100}$$

If we apply Dr. Shutt's formula to the data of this project we find that there is a continuous increase in the total amount of protein stored in the kernel from the early milk stage to the point where the crop was frosted, after which there apparently is a loss in total protein as well as other materials stored in the kernel. This loss of dry matter in the kernel is manifested by a lessening of the weight per thousand kernels, a lowering of the commercial grade, a change in the colour, a reduction in plumpness and a loosening of the bran.

In commenting on the protein data of this investigation, Dr. Shutt, under whose direction the protein determinations were made, stated: "Frosted immature wheat though high in protein (gluten) does not yield a flour of good milling quality. We must distinguish between *quantity* and *quality* of gluten when considering a wheat or flour from the standpoint of milling or bread-making value."

Whitcomb and Sharp (*18*), working with artificially frosted wheat cut at different stages of maturity, found that wheat collected when the moisture content of the kernels was 46.5 per cent or less, gave a better bread with respect to volume, texture and colour than normal wheat harvested at the same stage of maturity. Their experience was substantiated by the work of Johnson and Whitcomb (*8*), who found that wheat frosted in the medium dough stage with a moisture content of 44 to 46 per cent or less was equal in milling and baking quality to normal wheat.

Whitcomb, Day and Blish (*17*), working with naturally frosted wheat, found that the value of loaves, as determined by volume, colour, texture, flavour, crumb, size and shape, was higher when made from sound wheat than when made from frozen wheat, although the difference was not great

when the frost damage was slight. These findings agree with baking tests made with samples similar to those taken following the second frost reported in this paper. These tests made in the Cereal Division of the Central Experimental Farm, Ottawa, indicate that the internal changes which occur in the immature kernel as a result of freezing are reflected in milling and baking tests by high water absorption, lack of coherence of the gluten, poor loaf development and poor flour and crumb colour. Johnson and Whitcomb (8) report that viscosity tests indicate a change in the protein of a frosted wheat, as frosted wheat flours always exhibit lower viscosities than comparable normal wheat flours.

The protein data of this study when interpreted in the light of literature reviews indicate that there is still much to be learned concerning the milling value of frosted wheat. It would seem as though frosted wheat could be used more extensively for flour-making purposes if the full history of the wheat crop were known; otherwise the element of risk experienced by practical millers in using frosted wheat for milling purposes will continue, and result in a continuation of low prices for frosted samples. It would seem that the protein test is only one factor to be considered in estimating the milling value of a wheat sample.

Ash

It will be seen that the percentage of ash tended to decrease as the grain attained greater maturity but that there was little change after the grain attained the soft dough stage of maturity. There was no consistent change in the percentage of ash after the wheat was frozen, which tends to substantiate the theory that there is no appreciable reducion in the total amount of solids in the kernel as a result of frost damage. Johnson and Whitcomb (*8*) found that the ash content of flours milled from frosted wheats was in every case higher than that of flours milled from normal wheat, although the ash content of the wheats from which they were milled was the same. Their findings are in agreement with those of earlier investigators.

Grade and Price Per Bushel

The commercial grade and price per bushel at the local elevator are given for the different samples. It was believed that these data would throw additional light on the subject in question. It will be noted that the first two cuttings gave feed wheat and each succeeding cutting gave Nos. 6, 5, 4, 3 and 2 Northern respectively until the seventh cutting was reached. In all probability the eighth cutting would have given No. 1 Northern had the frost not occurred. The harmful effects of frost on the remainder of the cuttings are very marked. The wheat cut the same day it was frozen suffered a loss of two grades or 16 cents per bushel, that cut two days after being frozen suffered a loss of three grades or 28 cents per bushel, that cut four days after being frozen the second time suffered a loss of four grades or 40 cents per bushel and that cut six or more days after the first frost graded feed and suffered a loss of 47 cents per bushel. It would therefore seem a wise policy to cut wheat as soon as possible after the occurrence of

frost. It was observed that the damage from frost increased from day to day as long as the kernel contained any moisture and that the second frost increased the damage considerably.

The protein content of wheat is used extensively as a factor for establishing its baking value. In this series there is little correlation between protein content and the commercial grade or price per bushel. It would seem that factors other than protein content should be taken into consideration in establishing a value for wheat.

Champlin and Goulden (*5*) found that the quality of the flour is improved when the wheat is allowed to become dead ripe. Sherwood (*12*) found no direct relation between numerical grades and protein content of wheat and intimates that market values must be placed on other factors as well as protein content. The most important of these are yield of flour and cost of production. He found the cost of producing flour from wheats placed in the lower grades (because of weight per bushel) greater than that for wheats of higher grade, and that the baking quality of the flour is not necessarily correlated with the market grade of wheat. Nevertheless, he found that the market grade of wheat is a reliable index to the milling value of wheat when that term is applied to the monetary value of total products. Birchard (*3*) found that it is almost impossible to make standard patent flour from low grade wheat when clearness and ash were the basis used for comparison. The lower grades were found to produce flour which was "consistently of inferior quality". This was particularly true of frosted samples. In view of this evidence it would seem that there might be some justification for the differences between protein content and commercial grade of the samples from the different dates of cutting.

It is of interest that the second frost, although no more severe than the first, did much more physical damage to the kernel. This damage, although not markedly manifested in the grade and price per bushel, was very apparent in the form of kernel discoloration and loosening of the bran.

Relative Yield

Relative yields in percentages were calculated for ease in visualizing the relative productiveness of the different cuttings. The weight per thousand kernels was used as a basis for this calculation. The actual yield of each collection was taken and reduced to a percentage basis and compared with that based on the weight per thousand kernels. The values agreed so closely that it would make little difference which set of figures was presented.

It will be seen that the relative yield increased consistently from the lowest, the first cutting in the late milk stage, to the highest, the seventh cutting, in the soft to medium dough stage, but rapidly decreased after the crop was frosted, again illustrating the advisability of harvesting frosted wheat as soon as possible after frost occurs.

Relative Value Per Acre

The relative value per acre was calculated to form a basis for comparison from the producer's standpoint. In making this determination, the

seventh or highest yielding cutting was taken as the standard and was given the arbitrary value of 30 bushels per acre. The variates used in the different calculations were relative yield and price per bushel for the different grades represented.

It will be seen from the data presented that very serious losses may result from cutting wheat while too immature. It is of particular interest to note, however, that wheat can be cut as immature as the medium dough stage and develop into a sample that will weigh 64 pounds per bushel and command a No. 2 Northern grade. At this, the seventh cutting or medium dough stage, the kernels were still quite soft and had no indication of glazing and the straw was still green enough to make excellent green feed.

These data emphasize the importance of cutting wheat as soon as possible after freezing. It will be seen that the crop depreciated in value $4.82 per acre as a result of frost injury even when cut immediately after being frosted, but that this depreciation in value per acre continued after the second frost until the sixth day when the cutting gave a crop which graded feed netting a total loss of $16.04 per acre on a potential 30 bushel crop.

Bedford (*2*), Stoa (*15*), Ellis (*6*) and Harrington (*7*) found that under certain conditions there is little to recommend leaving wheat uncut after it has attained the stage of maturity where a reasonable amount of pressure must be exerted to dent the kernel. This investigation indicates that good wheat can be produced if cut as early as the medium dough stage. The writer believes that cutting as early as this is justified under conditions such as frequently obtain in districts subject to early fall frosts. This view is in agreement with Saunders (*10*), who suggests that harvesting in cool summers could be done two weeks before the grain is fully mature without serious loss.

Summary

Subject to the environmental conditions under which this work was done, the following conclusions are indicated:

1. Garnet wheat can be cut as early as the medium dough stage in a season with cool harvesting weather without sacrificing too much quality and quantity.

2. Frost damage interupts and prevents the continuance of the translocation of materials stored in the stems and leaves to the kernels.

3. Frost damage to an immature kernel tends to reduce in quantity those materials which go to make up the kernel.

4. Frost damage reduces the grade of immature wheat. This reduction is manifested in the commercial grade by change of colour, loosening of the bran and slight shrinkage of the kernel.

5. Grain damaged by frost while in the medium dough stage retains its moisture much longer as a standing crop than when cut and stooked under conditions which obtained at Lacombe in 1928.

6. Frost damage is cumulative and tends to increase from day to day as long as there is moisture in the kernel.

7. Frosted grain should be harvested as soon as possible after the occurrence of frost. The longer it remains uncut the greater the damage.

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A STUDY OF DISEASE RESISTANCE AND OTHER VARIETAL CHARACTERS OF WHEAT—APPLICATION OF THE ANALYSIS OF VARIANCE, AND CORRELATION.*

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Introduction

The essential problem in variety testing is the determination of inherent differences between the varietal units. If the measurable effects of these inherent differences are large as compared with the differences due to experimental error the test is a very efficient one, but if the converse is true the test is of little value. Thus the efficiency of the test depends upon the relative proportions of the two variances, the one due to inherent differences between the varieties, and the other to random variation within the test commonly referred to as experimental error.

On this basis the analysis of variance as developed by Fisher (*1*)‡ may be used to furnish valuable information as to the nature of a particular variety test. It enables us to determine the significance of the difference between the variance of the variety means and the variance due to experimental error. Then if we can assume with a reasonable degree of certainty that inherent varietal differences exist, we can measure the efficiency of the test; under these circumstances if the test is efficient, the varietal variance will be significantly greater than that due to experimental error. Also, we can use the same analysis to detect the presence of varietal differences. The varietal variance will be significantly greater than the variance due to experimental error only when there are real inherent differences between the varieties.

The value of an analysis of this kind became evident to the writers in examining, during the season of 1928, two groups of strains in the rod rows which were heavily infected with black chaff. One of these groups consisted of 86 strains from an H-44-24 × Marquis cross. In this cross the inheritance of resistance to black stem rust has been described (Goulden, Neatby and Welsh (*3*)), with special reference to the inheritance of a mature plant type of resistance which is governed apparently by a single pair of factors. The 86 strains tested in the rod rows for the first time in 1928 all possessed the mature plant type of resistance to rust which they inherited from the H-44-24 parent. This parent is susceptible to black chaff and since the hybrid strains in 1928 were severely affected it seemed possible that a close or perhaps a complete linkage might exist between the factors for susceptibility to black chaff, and rust resistance. The strains were uniformly rust resistant as far as could be determined from a test conducted in another part of the field in which a severe epidemic was produced artificially, and complete linkage of the two characters would therefore mean uniform sus-

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‡Reference by number to literature cited.

ceptibility to the bacterial disease. The latter varied a great deal from plot to plot so that although some strains were relatively free, it was impossible to determine from observation whether or not real inherent differences between the strains existed. It was here that the analysis of variance appeared useful, as the demonstration of significant varietal differences for susceptibility to black chaff would indicate incompleteness in the linkage with rust resistance. Selection of the strains least affected by black chaff would then be of real value.

The other group of strains consisted of 46 pure lines of Marquillo. These were even more severely affected by black chaff than the H-44-24 × Marquis lines and the analysis of variance was again applied in order to determine whether or not selection would be of any value. The parent stock of Marquillo from which the selections were made was somewhat mixed so that many of the selected lines showed considerable variation from the parental type.

The value of the analysis of variance in the determination of the significance of varietal differences depends upon the efficiency of the test. When the experimental error is large as in a test in which there are an insufficient number of replications, the demonstration of varietal differences is more difficult, i.e., the differences cannot be demonstrated unless they are quite large. In our rod row test of the above mentioned groups of strains there were only three replicates, so that the experimental error was relatively large and varietal differences could not be demonstrated unless they were proportionately great. Also in order to supply a background for the reliability of the method of analysis for a particular case, the data for several other characters including yield, strength of straw, and earliness, obtained from the rod row tests of 1925 and 1926, were subjected to the same type of analysis.

The Analysis of Variance

A complete discussion of the analysis of variance is given by Dr. R. A. Fisher in "Statistical Methods for Research Workers." From the standpoint of the ordinary field plot test the following equation is fundamental:

$$\sigma_T^2 = \sigma_V^2 + \sigma_R^2 + \sigma_E^2 \qquad \text{(1)}$$

Where σ_T^2 = total variance.
σ_V^2 = variance of the means of varieties.
σ_R^2 = variance of the means of replicates.
σ_E^2 = variance within replicates and which may be considered experimental error.

Expressing each variance in terms of the sums of squares of the deviations from the respective means, equation (1) becomes—

$$\frac{S(x-\bar{x})^2}{k\,n'} = \frac{S(\bar{x}_V-\bar{x})^2}{n'} + \frac{S(\bar{x}_R-\bar{x})^2}{k} + \frac{S(x-\bar{x}_V)^2}{k\,n'} \qquad \text{(2)}$$

Where x = yield of any one plot.
$\bar{x}$ = general mean.
$\bar{x}_V$ = mean yield of any one variety.
$\bar{x}_R$ = mean yield of any one replicate.
k = number of replicates.
n' = number of varieties.

Expressing (2) in terms of the sums of squares only, we have—

$$S\,(x-\bar{x})^2 = kS(\bar{x}_V-\bar{x})^2 + n'S\,(\bar{x}_R-\bar{x})^2 + S(x-\bar{x}_V)^2 \qquad (3)$$

In this equation the total sum of squares and the first and second term on the right can be calculated directly from the data. The last term on the right can then be equated from the other values.

Having obtained the sums of squares as in equation (3) each sum of squares is converted into a variance by dividing by the degrees of freedom. The significance of the difference between any two variances can then be determined by the test developed by Dr. Fisher. This test involves the transformation of the difference into a statistic known as z which is normally distributed and its significance can be tested by means of its standard deviation.

For testing the significance of the difference between the variance of the varieties and the variance within replicates z is given by—

$$\tfrac{1}{2}\left\{\log_e \frac{kS\,(\bar{x}_V-\bar{x})^2}{n'-1} \qquad \log_e \frac{S(x-\bar{x}_V)^2}{n'(k-1)}\right\}$$

and the standard deviation of z by—

$$\sqrt{\tfrac{1}{2}\left(\frac{1}{n'-1} + \frac{1}{n'(k-1)}\right)}$$

In the actual calculation of z it should be noted that natural logarithms must be used and that the most convenient method is to obtain the difference between the logarithms of the *square roots* of the two variances.

The method will be demonstrated by using yield data from the 1926 rod rows. These data are set forth in table 1 in the form of frequency distributions for the yields of each replicate and for all of the plots taken together. Note that the actual class interval which is 16 grams in this case is replaced by a class interval of one. This interval is adhered to throughout the calculations. From table 1 we calculate the means of the replicates and the total sum of squares. In table 2 are given the means of the replicates and the frequency distribution of the variety means. From these two we calculate the respective sums of squares and then proceed as in table 3 to the final analysis of the results. We find that the value of z is 2.34 times its standard deviation and conclude that the variance of the varieties is significantly greater than that due to experimental error. This can be taken also as a fair measure of the efficiency of the test as the 156 varieties tested were a heterogeneous group among which there was undoubtedly a considerable amount of variation in inherent yielding capacity.

TABLE 1. *Yield data from 1926 wheat rod rows given as frequency distributions by replicates and for all plots.*

Class Values	Rep'l I	Rep'l II	Rep'l III	Rep'l IV	Rep'l V	Total
1					1	1
2					2	2
3				2	2	4
4			4	2	1	7
5			1	1	4	6
6		4	9	3	5	21
7	1	8	7	3	4	23
8	3	8	15	9	6	41
9	4	6	18	12	9	49
10	1	3	13	6	11	34
11	1	12	7	9	13	42
12	8	16	17	15	4	60
13	9	18	6	14	12	59
14	3	12	11	16	10	52
15	9	6	7	12	15	49
16	12	11	7	6	8	44
17	12	7	8	6	14	47
18	11	10	5	3	7	36
19	23	6	4	11	6	50
20	11	5	5	7	6	34
21	12	5	3	7	3	30
22	11	1	3	2	5	22
23	8	6	2	1		19
24	4	6	2	3	3	18
25	5	2		2	2	11
26		1	1	2		4
27	2	1		2		5
28	3		1			4
29						
30	2					2
31		2				2
32	1					1
33					1	1
Totals	156	156	156	156	156	780

TABLE 2. *Frequency distribution of variety means for yields of 1926 wheat rod rows and means of replicates.*

Variety Means: Class Values	Freq.	Replicate Means: Repl.		
1	2	Repl.	I	18.3205
2	3		II	14.7885
3	10		III	12.4679
4	18		IV	14.1410
5	19		V	13.5320
6	24			
7	23			
8	19			
9	17			
10	10			
11	4			
12	5			
13	1			
14				
15	1			
	156			

TABLE 3. *Analysis of variance—yield data from 1926 wheat rod rows*

Variance of	Sum of squares	Degrees of Freedom	Variance	Standard Deviation	Log
Replicates	3081.84	4			
Varieties	5110.10	155	32.97	5.742	1.7478
Remainder	15180.21	620	24.48	4.948	1.5990
Total	23372.15	779			Diff. = .1488=z

$$\sigma_z = \sqrt{\tfrac{1}{2}\left(\frac{1}{155} + \frac{1}{620}\right)} = .0635$$

$$z/\sigma_z = \frac{.1488}{.0635} = 2.34$$

CORRELATION

In order to complete the study of the characteristics of the two groups of strains mentioned above, zero order and partial correlation coefficients were calculated for all possible pairs of the variables measured. This type of analysis determines the degree of association between pairs of characters for the material studied and is especially valuable in demonstrating the effect of disease upon yield.

Within the H-44-24 × Marquis group an additional study was made of the relation between awning and the other characters mentioned. The procedure consisted of drawing up contingency tables in which the distribution for any one character such as yield was compared in the awned and awnless classes.

The data from the 1925 rod rows were analysed and reported on previously by Goulden and Elders (*2*). It was found that stem rust and leaf rust were both negatively correlated with yield. In a similar study Hayes, Aamodt and Stevenson (*5*), obtained significant correlations between stem rust and yield and leaf rust and yield, and also between black chaff and yield. Using data from rod rows of oats Immer and Stevenson (*6*) demonstrated that crown rust in addition to other characters was closely associated with yield.

BLACK CHAFF

The principal object of this study was to obtain information relative to two groups of strains which were severely affected by a disease we have called black chaff. This disease has not been positively identified as the black chaff disease caused by *Bacterium transluscens var. unduloscum,* Smith, Jones and Reddy, and described by Smith (*7*), but it resembles black chaff very closely as the following description will show.

Infection was first observed in the cereal breeding nursery at Winnipeg in 1926; it was found only on the variety H-24-44 and its hybrids with Marquis. The infections were characterized by dark brown lesions more or less striated, extending down from the last node.

In 1927 the cereal breeding nursery was located at Morden, Manitoba. The disease appeared again and infection was much greater than in the previous year. The lesioning extended over the entire plant appearing first

just below the last node and later over the neck and head. Head and neck infections however, were patchy and rarely if ever continuous, as were lesions below the node. Besides the H-44-24 × Marquis hybrids, Kota and Pentad were also attacked.

In 1928 infection was still more severe, and practically all varieties and strains in the Winnipeg nursery were attacked in some degree. The effect on some varieties is quite different from that described for H-44-24 and the H-44-24 × Marquis hybrids. When visiting the nursery in August 1928, Dr. J. J. Christensen of the University of Minnesota observed that infected plants of the variety Marquillo were characterized by a scale of bacterial exudate over all infected parts of the plant. On most other varieties the presence of exudate could not be detected. The general appearance of the disease of Marquillo also differed from that of H-44-24, Kota, etc. The lesioning so characteristic of H-44-24 is absent; the discoloration being uniform, less intense, and usually extending over the entire culm and head. In an F_3 population of H-44-24 × Marquillo, the two types were very clearly segregated, only in a few cases were plants observed with both types of infection. In 1927 Marquillo strains growing adjacent to infected H-44-24 × Marquis were conspicuously free from disease. It is therefore open to question as to whether these two diseases are caused by the same organism.

Black chaff data in this study were estimated on a percentage basis. In the case of H-44-24 × Marquis strains a separate note was taken on heads, necks, and the region just below the last node. The estimates of infection on different portions of the plant were found to be closely correlated and on this basis they were combined in a mean value for the whole plant. On the Marquillo strains infection was very uniform for all parts of the plant so that one note only was taken.

Results and Discussion

1. *Analysis of Variance.*

The results of the analysis of variance are given in table 4 in the form of values of z divided by its standard deviation. When this value is 2 or more it indicates that the variance of the variety means is significantly greater than the variance within replicates, and we can take this to mean that actual differences between the varieties exist. It is evident from the table that such a value will vary from year to year depending on the efficiency of the test relative to the difference to be determined. Thus in 1925 considering yield we obtain a z/σ_z of 13.2, while in 1926 with practically the same group of varieties it is only 2.3. This is a logical result when we know the complete circumstances. A very heavy stem rust epidemic occurred in 1925 and affected the yields of the varieties according to their susceptibility. A great variation in susceptibility to rust resulted in a great variation in yield, the effect of rust almost completely obscuring the random error due to soil variation. In 1926 the effect of rust was negligible while soil variation was probably greater than for average seasons. The varieties therefore tended to yield more alike in proportion to the experimental error and this is reflected in the lower value of z/σ_z. This result demonstrates

also that a significant value of z gives evidence of the existence of varietal differences only in relation to the conditions of the test. Under a peculiar set of circumstances the group of varieties tested in 1925 and 1926 which undoubtedly possess real differences with respect to yielding capacity might give an insignificant value of z for the comparison of varietal variance with variance within replicates. It is obvious however that such circumstances would be rare. On the other hand a significant value of z cannot be obtained when real differences do not exist unless there is some systematic error in the planning of the test.

Again considering the yield results we note that z is significant for all varieties and for the H-44-24 × Marquis strains, while it is not quite significant for the Marquillo strains. The latter result appears somewhat paradoxical when we note, as shown in table 6, that there is a significant correlation between black chaff and yield, and from table 4 again that z is significant for black chaff. This is probably explainable on the basis that yield responds more readily to soil differences than does black chaff with the result that the differences are harder to detect. In a more extensively replicated plot test it is probable that the value of z for yield would be more significant.

Earliness was measured in two ways, as days from seeding to heading and as days from seeding to ripening. A comparison of these two methods of estimating earliness is possible from the values of z/σ_z for 1925 and 1926. In both cases z is highly significant but slightly more so when earliness is taken as days from seeding to heading.

For the H-44-24 × Marquis strains z for earliness is quite significant. While there is only a few days difference between the heading dates of the two parents, it was evident from observation of the strains that real difference existed. The Marquillo strains appeared more uniform for earliness and z/σ_z is lower than for the other group.

It is interesting to note the difference between the values of z/σ_z for height and strength of straw. The former are negative but quite insignificant while the latter are positive and significant. There are probably no significant height differences between the strains in both groups but height obviously varies considerably with soil differences and if such differences are present a much more extensively replicated test would be necessary in order to detect them with a reasonable degree of accuracy. Strength of straw appears, as would be expected, to be much less subject to variation with soil conditions. In 1925 two replications were quite sufficient to bring out the differences between the varieties.

In 1925 when a heavy stem and leaf rust epidemic occurred it was very easy to distinguish varying degrees of resistance among the varieties. It was evident in reading rust percentages on different plots of the same variety that the greatest source of error was in the estimation. In other words the actual random variation appeared quite small. It was observed however that there was a high correlation between the rust estimates for the two replicates and the two readings were therefore considered to be

sufficient. For the two replicates the values of z/σ_z for the estimates of stem and leaf rust are 10.5 and 11.5 respectively. This again demonstrates that the test on two replicates was quite sufficient.

The results of the analyses for black chaff are given in the lower part of table 4; z is quite significant in each case if we place the level of significance at $z/\sigma_z = 2$. This seems quite justifiable from the standpoint of general statistical procedure and also from the standpoint of the other values reported in table 4. Thus it seems reasonable to assume that real differences in the yielding capacity of the H-44-24 × Marquis strains exist, and the value of z/σ_z is 2.1. Also in 1926 a very heterogeneous group of varieties were tested and the value of z/σ_z is 2.3. The basis is sound therefore for concluding that there are real inherent differences for resistance to black chaff among both groups of strains. This is decidedly a valuable conclusion as it means not only that progress can be made in the selection of the most desirable of these strains but that progress can be expected in any other group of strains of similar parentage which are brought forward to the rod row test. If a linkage exists between mature plant resistance to stem rust and susceptibility to black chaff in the H-44-24 × Marquis cross it is evidently incomplete, and by growing large enough hybrid populations it should be possible to eliminate susceptibility to black chaff almost completely.

TABLE 4. *Values of z/σ_z for the analysis of eight varietal characters of wheat from results of rod row tests, 1925, 1926, and 1928.*

Character	1925 varieties	1926 varieties	1928 strains H-44-24	1928 strains Marquillo	1928 all varieties
Yield	13.2	2.3	2.1	1.8	3.2
Earliness (days to heading)	29.3	22.2	4.1	2.2	----
Earliness (days to mature)	26.2	16.5	----	----	----
Height	----	----	–0.11	–0.48	----
Strength of straw	(10.8)	17.1	4.1	4.7	----
Percentage Stem Rust	(10.5)	----	----	----	----
Percentage Leaf Rust	(11.5)	----	----	----	----
Percentage Black Chaff—					
Base	----	----	3.2	----	----
Culms	----	----	3.1	----	----
Heads	----	----	2.2	----	----
Mean	----	----	3.9	3.8	----

Note—Figures in parenthesis calculated from two replicates only.
The remainder for 1925 are calculated from four replicates.

2. *Correlations*

For the two groups of strains zero order and partial correlation coefficients have been calculated for the relations between earliness, height, black chaff, strength of straw, seed weight, and yield. These are given in tables 5 and 6. The symbols used to represent the different characters are as follows:

Y = yield
B = black chaff
E = earliness (days from seeding to heading)
S = strength of straw
H = height
W = weight of 500 kernels

Note also that "Student's" distribution of t has been used in order to determine the significance of the coefficients. The formulae given by Fisher (*1*) were used to calculate the values of t; these are—

$$t = \frac{r}{\sqrt{1-r^2}}\sqrt{n'-2}$$ for zero order coefficients

$$t = \frac{r}{\sqrt{1-r^4}}\sqrt{n'-2-v}$$ for partial coefficients where v is the number of variables eliminated.

If the value of t for any coefficient is 2 or more, the coefficient may be considered significant. In tables 5 and 6 we have given only those values of t that are 2 or more.

The correlation coefficients of most interest are those between yield and the other five variables. Note that those of zero order are all quite significant for both groups of strains. Considering the partial coefficients: in the Marquillo strains, yield is significantly correlated with black chaff, seed weight, and height; in the hybrid strains yield is significantly correlated with black chaff, seed weight, height, and earliness.

The correlations between black chaff and yield were quite to be expected considering the obvious effect of the disease on the general condition of the plants. This result demonstrates the economic value of resistance to black chaff if the disease should become epidemic.

The relation between yield and height is evidently a reflection of high yielding ability in its association with general vigour of the plants. Black chaff which is negatively associated with height as determined from the zero order coefficients evidently does not account for all of the relation between yield and height as the partial coefficients $r_{YH \cdot BESW}$ are both high.

Between yield and seed weight the partial correlation coefficients are slightly lower than those of zero order but still quite significant. The effect of black chaff is probably responsible for this difference.

For yield and strength of straw the correlations are quite interesting. This relation is significantly negative as determined by the coefficients of zero order but the partial coefficients are very low. This result is evidently due to the actual correlations between yield and height, and strength of straw and height. For the Marquillo strains we note that $r_{YH \cdot BESW} = .4744$ and $r_{SH \cdot YBEW} = -.5380$. As the yield increases we have greater height and a

TABLE 5. *Correlation coefficients for characters of H-44-24 × Marquis strains.*

Characters	Zero order Coefficients	t	Characters	Partial Coefficients	t
YE	–.3790	3.66	YE.BSHW	–.4530	4.42
YH	.6147	6.97	YH.BESW	.4996	5.03
YB	–.4991	5.15	YB.ESHW	–.2562	2.31
YS	–.2477	2.99	YS.BEHW	.0813	
YW	.4991	5.15	YW.BESH	.2632	2.38
BE	.2770	2.58	BE.YSHW	.1513	
BH	–.3534	3.38	BH.YESW	–.1236	
BS	.1401		BS.YEHW	–.0402	
BW	–.2475	2.28	BW.YESH	.0185	
ES	.0322		ES.YBHW	.1420	
EH	.0492		EH.YBSW	.3984	3.79
EW	–.0943		EW.YBSH	.0092	
SH	–.5189	5.43	SH.YBEW	–.5224	5.34
SW	–.0395		SW.YBEH	.2257	2.02
HW	.4446	4.44	HW.YBES	.2591	2.34

Multiple corelation $R_{Y \cdot BESHW} = .7853$

TABLE 6. *Correlation coefficients for characters of Marquillo strains.*

Characters	Zero order Coefficients	t	Characters	Partial Coefficients	t
YE	–.4894	3.72	YE.BSHW	–.2920	
YH	.5718	4.62	YH.BESW	.4744	3.41
YB	–.5352	4.20	YB.ESHW	–.4556	3.24
YS	–.5799	4.72	YS.BEHW	.1637	
YW	.6197	5.24	YW.BESH	.5308	3.96
BE	.0915		BE.YSHW	–.3216	2.14
BH	–.3500	2.48	BH.YESW	.2877	
BS	.6458	5.61	BS.YEHW	.5924	4.15
BW	–.2393		BW.YESH	.1959	
ES	.3831	2.75	ES.YBHW	.2699	
EH	–.2948	2.05	EH.YBSW	.0724	
EW	–.4745	3.54	EW.YBSH	–.1612	
SH	–.6390	5.51	SH.YBEW	–.5380	4.04
SW	–.3946	2.85	SW.YBEH	–.2354	
HW	.2100		HW.YBES	–.3212	2.14

Multiple correlation $R_{Y \cdot BESHW} = .8321$

weaker appearing straw. This causes the correlation $r_{YS} = —.5799$ which is reduced to $r_{YS \cdot BEHW} = .1637$ when the other variables are held constant.

Considering yield and earliness; in the H–44–24 × Marquis strains the partial and zero order coefficients are quite significant and very close to the same value. In this case it would appear to be a genetic relationship although further investigation of this point would be desirable. In the Marquillo strains the partial coefficient is much lower than the simple coefficient and this seems to be accounted for partly by the relations between earliness and strength of straw, height, and seed weight.

Among the H–44–24 × Marquis lines the association between awning and the other variables studied was determined by means of contingency tables for which values of χ^2 were calculated. These tables are given together in table 7, with the values of χ^2 and P. The evident relation between yield and the awned condition is very interesting. It is probably a physiological relation as previously pointed out by Hayes (*1*) who obtained similar differences between awned and awnless segregates from wheat crosses. The super-

iority of our awned strains seemed quite evident in the field. They produced plumper grain and appeared to be freer from diseases than the awnless strains. The association with yield however could not be due to a linkage between awns and resistance to black chaff as susceptibility to black chaff and the awned condition came from the same parent, H-44-24.

TABLE 7. *Contingency tables for relations between awning and earliness, height, black chaff, strength of straw, seed weight, and yield, in a group of lines from an H-44-24 × Marquis cross.*

	Earliness—days seeding to heading							χ^2	P
	65-67	68	69	70	71-72	Total	Mean*		
Awned	7	11	9	6	4	37	68.68	10.83	.029
Awnless	5	5	12	11	17	50	69.66		
	Height in inches								
	36-37	38-39	40-41	42-43		Total	Mean		
Awned	5	12	13	6		36	39.56	2.53	.476
Awnless	7	20	19	3		49	39.20		
	Black Chaff—percentage basis								
	6-15	16-25	26-40			Total	Mean		
Awned	9	24	4			37	18.44	6.54	.039
Awnless	3	37	10			50	21.90		
	Strength of straw—percentage basis								
	36-70	71-80	81-90			Total	Mean		
Awned	6	25	5			36	74.58	2.95	.230
Awnless	3	33	11			47	76.65		
	Seed weight—weight of 500 kernels								
	12.5-13.5	13.5-14.5	14.5-15.5	15.5-17.5		Total	Mean		
Awned	4	12	15	6		37	14.66	1.52	.682
Awnless	7	19	14	10		50	14.69		
	Yield—average yield in grams								
	151-200	201-250	251-325			Total	Mean		
Awned	6	7	21			34	245.6	15.87	.0004
Awnless	18	21	9			48	215.6		

*Means calculated from finer groupings.

SUMMARY

1. It is pointed out that Dr. Fisher's analysis of variance may be used to measure the significance of varietal differences.

2. The analysis of variance is discussed and the method of calculation demonstrated using yield data from the 1926 rod rows for 156 varieties and strains.

3. The analysis of variance was applied to data from rod rows of wheat grown at the Dominion Rust Research Laboratory in 1925, 1926, and 1928, considering the characters, yield, earliness, strength of straw, height, seed weight, susceptibility to stem rust, susceptibility to leaf rust, and susceptibility to black chaff. The 1928 rod rows consisted chiefly of a group of Marquillo lines and a group of hybrid lines from an H–44–24 × Marquis cross which were uniformly resistant to black stem rust. The differences for susceptibility to black chaff in both groups of strains were found to be quite significant and this is considered a very important result especially with reference to the hybrid lines as it indicates incompleteness of the linkage between resistance to stem rust and susceptibility to black chaff.

4. For the two groups of lines zero order and partial correlation coefficients were calculated for all possible pairs of the variables, yield, earliness, height, strength of straw, seed weight, and black chaff. In both cases significant negative correlations were obtained for yield and black chaff.

5. In the H–44–24 × Marquis strains it was found that the awned strains gave significantly higher yields than the awnless ones.

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CHEMICAL WEED KILLERS*

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This paper is not given with the intention of contributing any scientific data on the how, why and wherefore of the effect of chemicals on plant life, but rather as a review of chemicals already reported on, and as a statement of the observations of the effects of various treatments with chemicals, made by the staff of the Field Crops Branch of the Saskatchewan Department of Agriculture.

The use of herbicides for controlling or eradicating weeds on agricultural lands is a comparatively new practice; nevertheless it is one which is being used on an extensive scale in some countries. The spraying of large fields of grain, such as are found in the wheat-growing sections of the United States, has been resorted to in order to destroy the weeds in the growing crops, but the practice does not seem to have become general.

Under the system of grain growing in Western Canada, land which a few years ago was virgin soil and clean, is now more or less polluted with weed seeds, chiefly of annuals, which ripen and shell on to the ground before or during harvesting and re-pollute the soil. Summer-fallowing the land every few years is done for two purposes: (1) to conserve moisture, (2) to eradicate weeds. Unfortunately, however, the second purpose is accomplished very imperfectly under prairie conditions of light rainfall, especially in years when precipitation is lighter than usual. This is particularly the case when weed seeds of the mustard family, such as *B. arvenis*, *B. juncea*, *Thlaspi arvense* and, in addition, *Avena fatua*, are being dealt with, as many of them lie in the soil for years before germinating.

It is recognized that the adoption of suitable crop rotation and live stock will combat most weeds, but while the prairie soils remain fertile and grain growing possible, most farmers, human nature being what it is, will endeavour to follow the straight and narrow path of grain growing and not depart from it, remaining ever hopeful that some method of controlling weeds under such conditions will be discovered.

The Saskatchewan Department of Agriculture has, therefore, investigated some chemical means of weed control which will assist in making more perfect the imperfect results obtained by cultural means, and also provide a cheap and effective method of eradicating newly introduced weeds.

The problem divides itself into two divisions: (1) The control of weeds in growing crops, (2) The control of weeds on land either cultivated or uncultivated on which crops are not growing.

In considering division (1) it will be understood immediately that any chemical used must adversely affect the weed growth, but not the crop growth.

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Sulphate of Iron

Many authorities give sugar sulphate of iron credit for destroying most broad-leafed vegetation without seriously affecting cereal crops. Apparently there is a conflict of opinion as to what are the best weather conditions for spraying to obtain effective results. Selby (*1*) in Ohio prefers cloudy weather without rain. Olive (*2*) in South Dakota says, "The best time for the most successful work is just after the dew is off, on a bright sunshiny day. A little wind will also help the drying process." Warburton (*3*) of the United States Department of Agriculture says, "Spraying should be done, if possible, on a quiet, sultry day when rain is not probable for at least 48 hours. On a very hot dry day the spray dries off too rapidly. Spraying has not proved successful in the upper Great Plains area, owing to the prevailing high winds and low relative humidity." Bolley (4) of North Dakota says, "Iron sulphate should be applied in dry, clear weather, when there is no likelihood that rain will wash off the plants before the chemical has done its work."

Olive (*2*) thinks that as the spray dries the remaining dry salt draws the water out of the leaf cells causing wilting. The American Steel & Wire Company (*5*), which manufactures sulphate of iron for weed destruction, offers different opinions as to the effect and also the time of spraying.

No doubt, relative atmospheric humidity may necessitate different conditions for effective spraying, but some of these conflicting opinions are offered for sections of country having similar atmospheric and climatic conditions.

The Field Crops Branch of the Saskatchewan Department of Agriculture, therefore, purchased a two-horse traction sprayer and some sugar sulphate of iron in 1928 to determine if the solution is effective under Saskatchewan conditions for destroying weeds, particularly wild mustard, without seriously affecting the cereal crops in which they grow.

A number of experiments were outlined taking into consideration different stages of growth of the mustard and different weather conditions at the time of application of the solution, and three farmers in the Regina district offered to coöperate. Unfortunately, the spramotor was delayed in transit from Ontario and arrived too late for the earlier experiments. Applications were made on the farm of Alex. Fraser only, approximately five miles north of Regina.

Mr. John Cameron of our staff supervised the experiment and reported as follows:

The application: 100 lbs. per acre, the usual formula, giving a 20 per cent solution, was used, and the applications were made on July 16th, a medium cloudy day, the sun being behind the clouds about two-thirds of the time. The maximum temperature at Regina was 70°F. and a brisk wind from the northwest was blowing. A light rain had fallen the evening before. The applications were made on oats and in some cases on both oats and barley.

The oats were in the shot blade, approximately 30 inches high and heavily infested with wild mustard generally taller than the crop. Possibly

three-quarters of the pods had set and the seed was about one-half grown in the pods. The terminal flowers were still very prominent.

Results: Five days after application the leaves were quite generally stripped from the mustard plants, but the majority of the flowers and seed pods did not show any extensive injury. There was some blackening of the oat leaves, but probably not sufficient to affect the crop.

Six weeks after application the development of the mustard plants in all their stages appeared to have been definitely arrested at the stage they were in at the time of application. The seed set in the pods at that time showed, after six weeks, as small, poorly developed seed, but might have been viable. The oat crop showed no ill effects from the treatment.

An application was made on both oats and barley with a heavy infestation of mustard with pods half set, considerable stinkweed (*Thlaspi arvense*) pods set, and a lot of minor weeds.

Results: After five days it was estimated that half of the mustard was killed, the stinkweed was blackened and the leaves of the cereal crops noticeably blackened in places.

After six weeks it was apparent that the mustard was practically entirely killed, the plants showing as single blackened stems without any branches or pods. The stinkweed appeared as if scorched by fire with seeds small and mouldy in appearance. The blackened leaves of both the oats and barley were noticeable, hanging to the ripened straw, but the treatment did not appear to have adversely affected the cereals from a grain producing standpoint.

An application was also made on oats 10 to 12 inches high with medium infestation of wild mustard, and heavily infested with wild oats. The mustard plants were generally slim, stunted and in the early flowering stage.

Results: After five days 80 per cent of the mustard was killed with considerable blackening of the oat leaves, especially directly under the path of the sprayer nozzles.

After six weeks the mustard was practically entirely gone, even the stems being difficult of recognition on the ground.

Mr. Cameron, in his summing up, remarks that "all the mustard plants reached by the spray seemed to have been definitely arrested in the stage they were in at the time of application of the spray, and the great majority even of the more advanced plants were killed and seed production destroyed." He suggests that "best results would likely be obtained 30 to 45 days after seeding, and application on windy days should be avoided in order that the boom of the spraying machine might be raised high enough to secure an even distribution of the spray."

While the late arrival of the spramotor prevented us from carrying out all the experiments we had planned, we were able to determine that iron sulphate has some promise of being valuable for wild mustard destruction in grain crops under climatic and atmospheric conditions in Saskatchewan. The experiments will be continued this year.

The Stoldt Weed Killer

This chemical was also applied by Mr. Cameron on the same days as the iron sulphate and on the same farm. The composition of the chemical we do not know, but it was a white flocculated powder, readily soluble in water. Mr. Stoldt, of Melville, Sask., who supplied the powder and was present at the demonstration, recommends dry dusting, not later than 10 a.m., about 45 days after seeding. For this test, however, a solution was made up of one part of powder to four parts of water by volume. The solution was slightly acid and was neutralized by Mr. Stoldt before the application was made. The solution was applied with an ordinary watering can on wild mustard, in the late flowering stage, showing above an oat crop in the shot blade stage 28 to 30 inches high. The infestation was a heavy one and care was taken to wet all the plants thoroughly.

Results: After four days there was no doubt that the mustard, even in such an advanced stage, was killed; the pods which were set on the plants were shrivelled and blackened. There was slight blistering of the leaves of the oats, but probably not sufficient to do any harm.

A few plants of Canada thistle growing alongside were treated incidentally and showed extreme wilting.

After six weeks the mustard showed only as bare blackened stems without pod development of any kind and no trace could be found of the Canada thistle treated.

Sodium Arsenite

The effectiveness of this chemical as a soil sterilizer is well known. Our representatives have demonstrated it on agricultural lands and the writer has used it successfully on shale tennis courts and garden paths to destroy patches of grass which persisted in coming through. As a practical agricultural herbicide it cannot be recommended because of its poisonous properties, and the consequent danger to live stock. Insufficiently salted livestock lick the soil especially if it is alkaline, to satisfy their craving for salt, and pigs will even eat it. Live stock seem to prefer soil treated with sodium arsenite to untreated soil, and the danger from the chemical is, therefore, apparent.

Sulphuric Acid

The Field Crops Branch has not investigated the use of sulphuric acid as a means of controlling weeds.

Rebaté (6) indicates it is used in France to quite a large extent and states that its use could increase the crops of wheat of France by several million quintals. Apparently the treatment does not eradicate Canada thistle (*Cirsium arvense*) completely.

It would seem that the mode of preparing and applying sulphuric acid is not as "fool proof" as might be desirable.

Chlorates

Chlorates seem to give the most promise for totally eradicating almost all weeds, including running rooted perennials. The writer is not sure how effective they are on perennial grasses like couch or quack grass (*Agropyron repens*) although he believes they will respond to the treatment just as surely though perhaps more slowly, if a more concentrated solution is used.

In some parts of Saskatchewan there are weeds which are very difficult to control, the chief one of which is perennial sow thistle (*Sonchus arvensis*). The task of eradicating this weed from clumps of trees or bushes, and from waste, alkali and swampy lands, is practically superhuman. Consequently, farmers have been interested in chemical herbicides for some time, especially for use in such places. Their cost, however, has been prohibitive, and even those which can be mixed on the farm more cheaply, are poisonous and unsafe to use. A renewed interest in such chemicals has arisen since the introduction into Saskatchewan of a herbicide called the Atlas Non-Poisonous Weed Killer. Its non-poisonous properties appealed to the farmer first, its apparent efficiency next, and lastly its comparative cheapness.

In 1927 and again in 1928 the Field Crops Branch obtained some of the liquid in concentrated solution for dilution. The intention was to apply it on some patches of perennial sow thistle on the banks of a dam which the Government had constructed to provide a water supply for settlers. By the time the solution was received in the fall of 1927, the thistles had frozen down and the solution was not used. It was sprayed on to the new plants on June 4th, 1928, and within 24 hours a heavy rain fell. Our representative, Mr. W. J. Mather, who applied the chemical, visited the patch on June 7th, just 3 days after the application, and reported that the plants had wilted but expected the heavy rain would revive them. On July 14th, 10 days after the application, he was amazed at the success of the demonstration, stating that on over 80 per cent of the area there was no new growth, and that the balance was apparently plants which had not appeared at the time of treatment.

Our representative, Mr. W. G. Palmer, treated both perennial sow thistle and Canada thistle in the Canadian Pacific Railway yards, Regina. The solution was applied with a watering can. In eight days the leaves had gone, the stalks were still green, but the roots affected. At eight weeks, the time of the next inspection, the stubs of the stalks remained and the roots of both kinds of thistles were decayed as far as could be traced. Mr. Palmer treated another patch of Canada thistles at Tyvan and in three weeks the roots were entirely dead. He states that in his opinion, the chemical destroys Canada thistle more quickly than perennial sow thistle.

Our representatives, E. Waddington, L. M. Ogilvie, A. Dumais and L. J. Hutchison, have all submitted similar reports stating their conviction, based on observations, that the Atlas chemical seems to be 100 per cent effective, but even if not, it is so nearly so that it is worth while using, even if a second application is necessary to destroy the few odd plants not affected by the first application.

Latshaw and Zahnley (7) have reported that sodium chlorate used as a spray will kill field bindweed in Kansas quickly and efficiently and without injury to the soil or danger to grazing livestock. Apparently, however, more than one application is necessary.

The University of Saskatchewan, under the direction of Dr. Thorvaldson, kindly made an analysis of the Atlas Weed Killer and reported as follows:

Specific gravity	1.35 per cent.
Total solids	38.5 per cent.

The solution was found to contain—

Sodium chlorate ($Na\ Cl\ O_3$) 25 per cent.
Calcium Chloride ($Ca\ Cl_2$) 14 per cent and a trace of coloring matter.

Why the calcium chloride is present, we do not know. It may be present as a commercial impurity of the chlorate used. It may be added in order to retain moisture when the spray dries and thus prevent the residue from drying off altogether and blowing away.

Just why sodium chlorate affects the plants as it does is not known.

Aslander (*8*) treated Canada thistle by spreading the dry salt on the ground and his experiments indicated that its effectiveness was due to its rapid penetration through the soil and its slow decomposition. While this may be true, it does not explain the effectiveness when the spraying method is used.

Our Mr. Waddington treated a dense luxuriant growth of perennial sow thistle with Atlas and destroyed it, but found the dandelions in the bottom unaffected. A second application was given and the dandelions succumbed. It would seem that the thistles which were tall growing had received the spray, but had sheltered the dandelions. Obviously the spray had not reached the ground, as there is no other reason why it should have singled out the thistles and left the dandelions. It seems apparent that the chemical had taken effect from the upper portions of the plants and downwards throughout the whole plant system. It has been suggested that some chlorates have a strong affinity for hydro-carbons and this may explain their activity.

Copper Nitrate

Another chemical used this year was "Raphanit" which was imported from Germany. The University of Saskatchewan reports this to be a solution of copper nitrate, specific gravity 1.425, containing about 15 per cent of copper nitrate $Cu(NO_3)_2$. It was used in spraying perennial sow thistle in north-eastern Saskatchewan, and it killed it completely. We have not yet tested it for the destruction of weeds in grain crops, for which it is intended.

Oils

Kerosene, fuel oil, and lubricating oil from the crank cases of automobiles and tractors act as soil sterilizers, but their cost is prohibitive unless some of them can be obtained from garages for almost nothing.

Costs of Chemical Herbicides

The cost of sugar sulphate of iron, laid down at Saskatchewan points in less than carload quantities averages about $3.40 per cwt., which is the amount required for one acre.

For treating 400 sq. feet the cost of the different materials is:

Fuel oil	$8.00
Atlas	.85
Tar paper	3.70

These costs can be reduced by buying in carload quantities.

When perennial weeds generally infest a field, intensive tillage methods are still the most economical means of control. This class of weeds, however, usually becomes established first in small patches, and even with intensive cultivation there is always the danger of distributing the weeds by dragging small pieces of root around and depositing them in other places on the field. If a cheap effective herbicide can be obtained which will eliminate such weeds without disturbing them, a tremendous saving in time and labour will be effected.

These experiments have been sufficiently satisfactory to warrant continuation. Other chemicals, which are also sodium chlorate solutions, have been offered for trial and these will be tested next year.

The point should be emphasized that in districts generally infested with weeds, tillage and cropping practices are still our chief means of control. Chemicals are yet too costly for use on large fields, but may be used to eradicate patches of weeds newly introduced into a district, or patches of weeds which are in more or less inaccessible places for mowing or tillage machinery, and also to eliminate the laborious process of hand digging. Chemical weed spraying is a labour and time saving device. Though apparently expensive, it may be considered economical if it stems the onward rush of the enemy into unoccupied territory.

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FISH OILS AS SOURCES OF VITAMIN D FOR POULTRY

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Cod liver oil has been used in large quantities in poultry foods since it was established that it can be used to prevent rickets. Other fish oils have also been found to possess antirachitic properties. Among these is the oil from California sardines, which, according to Bills (*1*) is equal in this respect to cod liver oil. Bills (*1*) also tested dog fish liver oil (Newfoundland) but found it to be only 3 per cent as potent as cod liver oil. Brocklesby (*2*) in extensive tests on dog fish liver oil from fish caught in British Columbia waters found that the vitamin D content was much lower than that of cod liver although in some cases apparently higher than shown by Bills. The variability in potency of oil from different fish noted by Brocklesby may account for the apparent discrepancy.

The object of the trials reported in this paper was to determine whether oils from various fish caught off the coast of British Columbia contained sufficient vitamin D to make it feasible to use them for poultry in place of cod liver oil.

Oil from the livers of dog fish (*Squalus sucklii*) caught off the east coast of Vancouver Island was used in all the trials. The oil, which had been prepared as described by Brocklesby, was secured through the courtesy of commercial firms in Vancouver. Pilchard (*Sardinia cerulea*) oil was also used in two experiments. This is a commercial product secured from the pilchard, or mature California sardine, caught off the West coast of Vancouver Island. The oil is prepared as follows:

Pilchards are caught in purse seine nets and transported immediately to the reduction plant where the whole fresh fish is placed in a continuous cooker for a period of from twenty to thirty minutes and then passed from the cooker into a California screw press or in some cases a Hydraulic steam press. From there the oil passes into the first settling tank having a temperature of 180°F. and then passes into three successive tanks varying in temperature from 125 to 75°F. In the last tank the oil is allowed to settle prior to shipment. Oil generally varies in colour from a yellowish shade to a dark brown, analysis running 1 per cent free fatty acid, about 1 per cent water and volatile matter, and 0.01 per cent insoluble matter.

The cod liver oil used was a medicinal oil put on the market by Parke Davis & Co., and stated to contain 1600 units of vitamin D.

Experimental

The preventive type of experiment was used, the chicks being started on the experimental rations when two days old. A ration similar to that outlined by Hart, Steenbock, and Lepkovsky (*3*) was used. It consisted of 97 pounds of yellow corn, 2 pounds of calcium carbonate, 1 pound of sodium chloride and 10 pounds dried skimmed milk. The amount of dried skimmed milk was increased to 15 pounds after the first three weeks in the second series of experiments, and maintained at that amount for the third and sub-

sequent series. This basal ration was adopted after two trials, with a ration having a better balanced mineral content, had shown that the chicks would not exhibit rickets on a well balanced ration within a period of seven weeks. The food (dry mash) was left before the chicks all the time in troughs, and water to drink was supplied in fountains. Two per cent of the oils was used. This was mixed with the mash at intervals of not more than two weeks.

The chicks were confined indoors in cages similar to those described by Carrick (*4*) and did not have access to direct sunlight at any time. Twelve to fifteen chicks were usually placed in each cage but only six were used for the ash determination. In each series the chicks receiving the oils to be tested were compared with chicks receiving the basal ration only, and with the chicks receiving the basal ration supplemented with cod liver oil.

The criteria used to ascertain whether the rations protected the chicks from rickets were the incidence of "leg weakness" and the characteristic enlargement of the ends of the long bones (see Fig. 1). When the chicks used as controls, which were fed the basal ration without any oil, had developed severe cases of rickets, six chicks from each group were weighed and then killed, the tibia freed from fat and the ash content determined by the method described by Hart, Steenbock, and Lepkovsky. Since the observed symptoms agreed closely with the variations in the ash content of the tibia, only the latter are given.

Pilchard oil

Cod liver oil

Dog fish liver oil

Control.

FIGURE 1. Photograph of legs of chicks showing difference in size and contour. The supplement fed is indicated in each case.

A summary of the results obtained in five series of experiments is given in table 1, evaluating those for cod liver oil at 100. The data presented show that the ash content of the tibia was relatively more variable than the weight. It is also apparent that the slight difference in the temperature at which the dog fish liver oils were rendered (series 1) had no effect on the results. Furthermore, it will be observed that the commercial and medicinal cod liver oils used in the fourth series gave practically identical results.

TABLE 1. *Comparison on a percentage basis of the average ash content of the tibia and the average weight for 6 chicks from each of 20 groups comprising five series of trials.*

	SERIES 1		SERIES 2		SERIES 3		SERIES 4		SERIES 5	
Oil supplement	Ash	Wt.	Ash	Wt.	Ash	Wt.	Ash	Wt.	Ash	Wt.
None	68.20	88.82	68.58	91.25	78.38	98.39	75.83	99.71	80.65	95.94
2% dog fish liver oil (212°F.)	77.78	110.39	75.69	95.55	75.02	98.99	85.99	105.00	80.62	99.26
2% dog fish liver oil (190°F.)	76.17	110.27								
4% dog fish liver oil (212°F.)			72.05	90.78						
2% cod liver oil (medicinal)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
2% cod liver oil (commercial)							98.63	103.06	100.00	100.00
2% pilchard oil					82.32	94.35			92.95	98.15

The detailed results of two series of experiments (Nos. 2 & 3) are given in table 2. In the first series the ash content of the tibia of chicks receiving dog fish liver oil, while higher than that of chicks receiving only the basal ration, was considerably lower than the ash content of the tibia from those chicks receiving cod liver oil. In the second series the average ash content of the tibia from the chicks receiving dog fish liver oil is slightly less than that for the chicks receiving no oil. It is apparent that increasing the amount of oil to 4 per cent did not improve the results.

TABLE 2. *Comparison of ash content of tibia and weight of chicks receiving cod liver oil, dog fish liver oil, and pilchard oil. The chicks in series 2 were 49 days old; those in series 3, 46 days old.*

No.	Ash %	Weight gm.	No.	Ash %	Weight gm.
		SERIES 2			
Control			2% dog fish liver oil		
2	35.47	261	20	35.49	163
17	36.13	291	27	38.70	201
39	31.47	278	33	29.54	316
55	29.32	200	57	34.60	354
85	34.62	194	98	44.08	193
89	32.06	153	108	37.33	215
Average	33.18	229.5	Average	36.62	240.3
2% cod liver oil			4% dog fish liver oil		
8	53.49	204	18	34.18	289
19	46.05	184	21	45.31	194
26	47.28	300	24	35.22	213
43	51.35	322	29	26.49	187
48	42.98	259	44	39.49	136
49	49.14	240	63	28.48	351
Average	48.38	251.5	Average	34.86	228.3
		SERIES 3			
Control			2% dog fish liver oil		
173	33.09	297	51	27.68	255
175	31.28	200	117	29.41	264
179	30.55	264	190	27.19	297
193	31.85	254	203	36.01	222
214	32.86	215	219	32.77	193
215	29.03	248	227	27.48	240
Average	31.44	246.3	Average	30.09	245.2
2% cod liver oil			2% pilchard oil		
174	41.63	216	82	30.98	216
180	39.02	224	140	36.47	195
187	41.43	240	152	33.29	238
196	38.47	252	183	32.98	285
206	40.87	289	184	31.59	202
221	39.22	267	210	32.83	268
Average	40.11	248	Average	33.02	234

An interesting point in connection with these trials is the greater variation in the ash content of the tibia from chicks receiving dog fish liver oil than for those receiving only the basal ration or the basal ration plus cod liver oil or pilchard oil.

The results with dog fish liver oil agree with those obtained by Brocklesby, in that they indicate that some samples of this oil contain appreciable amounts of vitamin D, but that even in the case of such samples, the potency of the oil is so much lower than that of cod liver oil that it cannot be considered a suitable substitute for the latter in poultry rations.

The pilchard oil tested apparently contained vitamin D, but was less potent than the cod liver oil. The results of these trials differ in this respect from those reported by Bills, mentioned above. The greater potency of the oil tested by Bills may be due to (1) a higher vitamin content in oil from young fish of this species, or (2) the variation may be due to a difference in the vitamin content of the samples tested. Such differences have been noted for various samples of cod liver oils by Heuser and Norris (*5, 6*) and others. The ash content of the tibia from chicks receiving cod liver oil or pilchard oil was less variable than that of chicks receiving dog fish liver oil. The greater uniformity of the ash content of the tibia from chicks receiving pilchard oils would seem to indicate that pilchard oil is a better source of vitamin D than dog fish liver oil. This also agrees with the observation that fewer of the chicks receiving pilchard oil exhibited leg weakness than did those receiving dog fish liver oil. There is comparatively little difference in the average weights of the various groups of chicks. The chicks receiving 4 per cent dog fish liver oil and the chicks receiving the basal ration in the first and second series only weigh less, on the average, than those receiving cod liver oil, but the difference is not statistically significant. Steenbock and co-workers (*7*) suggested that the decreased rate of growth of rats noted by them was due to lack of vitamin D and this was confirmed for the rat by Soames and Leigh-Clare (*8*). Heuser and Norris observed indications of decreased growth of chicks on rations low in vitamin D. The results of the trials reported in this paper apparently indicate that chicks will not definitely show the effects of vitamin D deficiency on growth unless kept on deficient rations for more than 7 weeks.

Summary

Experiments with chicks indicate that dog fish liver oil contains vitamin D, but that the potency varies rather widely, and is decidedly lower than that of cod liver oil.

Pilchard oil gave more uniform results and appeared to be a better source of vitamin D than dog fish liver oil, but was not so potent as the cod liver oil used.

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A BASIS FOR THE VALUATION OF MALTING BARLEY*

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The methods for the valuation of malting barley vary according to the type of barley produced and the purpose for which the malt is to be used. Wahl and Henius (*1*) draw attention to this condition as particularly applying to the United States. The malsters in different crop regions, and even different malsters in the same region, often have different standards of excellence for malting barley. This fact was made very evident by the results of several samples sent to British malsters by the writer. While the standards may differ, the same properties of the barley are usually considered. The different standard is due to the importance that is attached to each factor. For instance the British and Continental malster stresses brightness of kernel, while the Canadian malster does not lay so much emphasis on this character. The brewer wants malt with a large kernel and a high percentage of starch and sugar, while the distiller will use a small kernel that must be high in diastatic activity.

In the evaluation of malting barley there are four general charactertistics that can be considered: first, cost of preparing the barley for malting, i.e. drying, cleaning, etc.; second, ease of malting, i.e. uniformity of germination under varying conditions, absence of moulds, etc.; third, quantity of malt produced from a definite amount of barley; fourth, the quality of the malt produced.

Cost of Preparing for Malting

The largest cost in preparing barley for malting is the removal of impurities such as weed seeds, other grains, broken kernels, chaff, straw, etc. Most of these impurities are removed by mechanical means, using the size, shape, weight and specific gravity as a means of making the separation. In most malt houses this separation is made in the workhouse of the elevator unit. It is done by means of a general scalping machine and then special machines such as indent cylinders, disc machines, needle machines, etc. The cost is dependent on the time required to make the separation, the loss due to the removal of the impurity and the loss in the barley going out with the impurity.

After the grain has been cleaned there is a further separation made, usually in the steep tank, of the light weight kernels of barley. These are floated to the surface and skimmed off, hence the name skimmers. They have then to be dried and ground and sold as a cheap feed product.

In the manufacture of malt it is very essential that the kernels be of uniform size and in most cases the large sizes are preferable. It is therefore necessary, before malting, to have the barley separated into various sizes. This is done on a regular sizing machine, and the time is charged to the cost of preparing the barley.

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Another cost is the drying of grain carrying an excess of moisture. This is difficult even with wheat for flour manufacture, but is more difficult with barley for it must be done at such low temperatures that the germ is not injured. It is therefore considerably more expensive than the commercial drying of wheat.

Before good germination can be secured most seeds must go through an after-harvest ripening period. The ripening can be hastened by reducing the moisture in grain and the commercial drying of all barley used in the malt house is practised by some, especially in the early fall months. This has to be done slowly and carefully with considerable expense. Kropff (*2*) shows that this is essential in new barleys of low germinative capacity. O. Munerati (*3*) shows this has to be done very carefully at low temperatures. Therefore the cost of preparing the barley for malting depends upon extraneous matter, skimmers, uniformity of kernel, and amount of moisture in the kernels.

Ease of Malting

There is a great difference in the ease with which some barleys can be malted as compared with others. In malting the barley is first steeped in water until there has been sufficient absorption to start the germination processes. It is then sprouted for a given length of time and finally dried.

The ease and uniformity with which a barley will absorb water is important, otherwise the germination will be uneven. Some sorts absorb quickly and uniformly while others absorb slowly and unevenly.

The malster's aim is to have every kernel germinate at the same time and give a uniform growth while in the germination compartments. With some barleys the ability to do this is much more marked than with others. A variety like O.A.C. No. 21, for example, gives a high uniform germination with a uniform growth within certain limits, regardless of environmental conditions, while a variety like Trebi requires more exacting conditions. J. Raux (*4*) states that "Fungous growth on the germinating barley are an important factor in the ease of malting. Barley with the germ ends blackened with disease is apparently more prone to fungous growth than clean bright barley. Fungous growth is also more prevalent on weathered, field sprouted, broken and peeled kernels. While the fungous growth can be controlled to some extent in the malting process, when the barley is injured as above it is much more difficult".

While barley discoloured by rains or dirt may be made into good malt, it is more difficult. The discolouration must be removed in the steep tank. In areas where barley is liable to be discoloured malt houses are usually equipped with washing apparatus, such as a continual flow of water through the steep tanks and the agitation of the barley by means of compressed air. This adds, however, to the difficulties of malting because one can never be sure that the discolouration will all be removed and in some cases it is evidence of lowered vitality. The factors affecting the ease of malting may be summarized as follows: (1) ease and uniformity of water absorption, (2) ease and uniformity of germination, (3) absence of diseased

kernels, sprouted kernels, weathered kernels, broken or peeled kernels, and (4) the colour of the barley.

Yield of Malt

A large quantity of malt from a given quantity of barley is desired by all malsters. This can only be determined by an actual malting test. The weight of the malt divided by the weight of the barley (both barley and malt calculated to the same moisture basis) and multiplied by 100, gives the per cent of malt. This will vary from 60 per cent to 80 per cent. The size of the kernel and the rootlet growth give some indication of the loss in malting. Of course, a great amount of the loss is due to the evolution and loss of carbon dioxide gas during the germination processes.

Quality of Malt

The quality of the malt produced is one of the most important factors in the evaluation of malting barley. While the quality of malt can be varied considerably by the method of malting, it is also dependent to a very large extent on the quality of the barley. It is determined by the size of kernel; for brewing and most other malt products a large kernel is favoured, while for distilling a smaller kernel is preferred. The thinner the hull the greater the amount of extract, although under certain conditions thicker hulls are desired; for example, if a quick drainage of the tun is required a thick hull may be an advantage.

Low protein is desired because it indicates high starch which converts to more sugar by the action of the enzyme diastase. The proteins also undergo degeneration by the action of enzyme protease. Too large an amount of these simpler nitrogen compounds is objectionable.

The mellowness of the malt indicates that the modification of the starch has been complete and that the starch is in better condition to be acted upon by the diastase in the mashing process.

The growth of the acrospire, in proportion to the length of the kernel, is an indication of the amount and uniformity of modification that has taken place in the kernel. This is reported as length of acrospire in proportion to the length of the kernel and is designated as the percentage from 0 to ½, from ½ to ¾; and from ¾ to 1. The extract is the most important determination. In this test the malt is extracted and the soluble material in the extract is measured. The barley giving the greatest amount of soluble material per given quantity is considered superior.

Interpretation of the Malting Data

As indicated at the beginning of this paper the interpretation of these data is different in different crop areas and when the malt is used for different purposes.

Different standards have been suggested and used in Great Britain. R. V. Reid (*6*) under the heading "The Barley which Buyers Want" suggests: (a) Barley of Chevalier class; (b) Grown on barley land; (c) Well

ripened: (d) Good shape; (e) Uniformity; (f) Carefully threshed; (g) Less than 1.6 per cent nitrogen; (h) Free from weeds; (i) Capable of producing good malt.

H. M. Lancaster and L. Lloyd Hind (*8*) have used in their reports on malting, analytical results on the following properties:

1. *Barley*: (a) Moisture content; (b) Weight of 1000 grains; (c) Nitrogen in per cent; (d) Amount of extract.

2. *Malt*: (a) Moisture content; (b) Extract; (c) Colour; (d) Diastatic power; (e) Cold water extract.

In another publication H. M. Lancaster (*9*) suggests, in addition, the use of flavour as an important point in valuation.

Berlin Method (*9*)

A. *Properties for Valuation*—1, Albumen content; 2, Colour; 3, Uniformity; 4, 1,000 berry weight; 5, Fineness of husk; 6, Mellowness; 7, Extraneous matter; 8, Damaged kernels; 9, Odour; 10, Sprouters.

B. *Valuation*—For the valuation of properties enumerated under 1 to 7, 1 to 9 points are awarded, and in the case of the more valuable properties (albumen content, 1,000 berry weight, uniformity as to size and fineness of husk) the points awarded are multiplied by 2. The sum of the points awarded are, according to the nitrogen content, reduced as given in table 4. From this reduced sum of points, deductions are made for properties enumerated under 8-10, for each of which, deductions from 1 to 24 are made. This final sum of points awarded expressed the total value of the barley.

Table 1. *Albumen content*

Albumen content in dry substance. (Per cent.)	Points awarded
Over 14.0	1 × 2 = 2 points
13.1 to 14.0	2 × 2 = 4 "
12.1 to 13.0	3 × 2 = 6 "
11.6 to 12.0	4 × 2 = 8 "
11.1 to 11.5	5 × 2 = 10 "
10.6 to 11.0	6 × 2 = 12 "
10.1 to 10.5	7 × 2 = 14 "
9.0 to 10.0	8 × 2 = 16 "
Under 9.0	9 × 2 = 18 "

Table 2. *1,000 Berry Weight*

1,000 Berry Weight in dry subtance (Grams)	Points Awarded
Under 30.0	1 × 2 = 2 points
Over 30 to 34.9	2 × 2 = 4 "
" 35 to 37.9	3 × 2 = 6 "
" 38 to 40.9	4 × 2 = 8 "
" 41 to 42.9	5 × 2 = 10 "
" 43 to 44.9	6 × 2 = 12 "
" 45 to 46.9	7 × 2 = 14 "
" 47 to 48.9	8 × 2 = 16 "
" 49.0	9 × 2 = 18 "

Table 3. *Uniformity as to size*

The sum of the screenings, I + II or + III (Per cent)	Points awarded
Under 50	1 × 2 = 2 points
50 to 60	2 × 2 = 4 "
60 to 70	3 × 2 = 6 "
70 to 75	4 × 2 = 8 "
75 to 80	5 × 2 = 10 "
80 to 85	6 × 2 = 12 "
85 to 90	7 × 2 = 14 "
90 to 95	8 × 2 = 16 "
Over 95	9 × 2 = 18 "

Table 4. *Reduction of points awarded*

Sum of points awarded (I) must not be higher than:

16 points	if albumen content	awarded		2	point
26	"	"	"	"	4	"
37	"	"	"	"	6	"
48	"	"	"	"	8	"
59	"	"	"	"	10	"
70	"	"	"	"	12	"
81	"	"	"	"	14	"
92	"	"	"	"	16	"

Vienna Method (Bonitierungssystem)

A. *By objective examination in the laboratory.*

1. Hectoliter Weight

Over 70 kg.	3 points
67 kg. to 70 kg.	2 "
66 kg. to 66.9 kg.	1 "
Under 66 kg.	0 "

2. 1,000 Berry Weight

Grams	
Over 38.5	3 points
36.5 to 38.4	2 "
35 to 36.4	1 "
Under 35	0 "

3. Screenings

Per cent	
0.0 to 1	4 points
1.1 to 2	3 "
2.1 to 3	2 "
3.1 to 4	1 "
4.1 to 5	0 "

4. Extraneous Matter

Per cent	
0.0 to 0.2	4 points
0.3 to 0.5	3 "
0.6 to 1.0	2 "
1.1 to 1.5	1 "
Over 1.5	0 "

5. Real Per Cent Steeliness

Per cent	
0 to 10	6 points
10 to 20	5 "
20 to 30	4 "
30 to 40	3 "
40 to 50	2 "
50 to 60	1 "
Over 60	0 "

6. Albumen Content

Per cent	
Under 10	6 points
10.0 to 10.4	5 "
10.5 to 10.9	4 "
11.0 to 11.4	3 "
11.5 to 11.9	2 "
12.0 to 12.9	1 "
13.0 and over subtract	2 "
14.0 and over excluded.	

B. *Subjectively by the jurors.*

7. Colour

Very good	3 points
Good	2 "
Medium	1 "
Poor	0 "

8. Uniformity as to Size

Excellent	4 points
Very good	3 "
Good	2 "
Poor (inferior)	1 "
Very poor	0 "

9. Form of Berries

Excellent	4 points
Very good	3 "
Good	2 "
Poor (inferior)	1 "
Very poor	0 "

10. Fineness of the Husk

Extraordinarily fine	6 points
Very fine	5 "
Fine	4 "
Fairly fine	3 "
Rather coarse	2 "
Coarse	1 "
Thick skinned	0 "

11. Odour

Slight odour, deductions to	2 points

12. Damaged Kernels

Deductions to	2 points

13. General Impression

Excellent	3 points
Very good	2 "
Good	1 "
Poor	0 "

Robert Wahl *(11)* suggests that for American barley four methods be adopted because of distinct differences in the barley of that country:

1. Eastern six row Manchuria barley.
2. Western six row Bay Brewing.
3. Six row White Club barley.
4. Two row Chevalier, Hanna and Goldthorpe, etc., barley.

He then gives a quite elaborate table, setting forth the difference in evaluating the various properties. A general summary of his method of evaluating the various factors is as follows:

Tentative American Method

	Deductions
A. *By subjective examination*	
1. Colour	1 to 6 points
2. Odour	1 to 6 "
3. Form of berries	1 to 6 "
4. Thickness of husk.	1 to 6 "
B. *By objective examination.*	
1. Screenings	2 points for every per cent
2. Extraneous matter (foreign seeds or damaged kernels).	3 " " " "
3. Sprouters	6 " " " "
4. Uniformity as to size (The sum of screens, 2.8 mm. + 2.5 mm. or 2.5 mm. + 2.2 mm. or 2.2 mm. + 2.0 mm. giving the highest figure).	
100 to 80 per cent	0 point
80 to 74 "	1 point
74 to 69 "	2 points
69 to 65 "	3 points
65 to 62 "	4 points
62 to 60 "	5 points
60 to 58 "	6 points
5. Moisture	2 points for every per cent above 11 cent.
6. Albumen	3 points for every per cent above or bel optimum.
7. 1,000 berry weight	2 points for every per cent above or bel optimum.
8. Germinating capacity	1 point for every per cent below 100 per ce
9. Uniformity as to variety	2 points for every per cent of foreign b leys of the different groups (2 or 6 ro ed barleys).
10. Skimmings	2 points for every per cent.
11. Husk	3 points for every per cent above optimur

A malting barley is considered standard when it is given from 94 100 points and below standard when it receives less than 94.

Tentative Canadian Method

After considering the quality of barley produced and the purpose f which the malt is used, the following is suggested as a method for obtai ing a single figure value for Canadian malting barley.

Scheme for Evaluation of Canadian Barley

1. *Cost of preparing barley for malting.*

(a) Extraneous matter 25
One point reduction for each one per cent of impurities.

(b) Uniformity of size 30
One point reduction for each four per cent below perfect.

(c) Skimmers 25
Two points reduction for each one per cent of skimmers.

(d) Moisture 20
One point reduction for three per cent of moisture up to 15%, then two point reduction for each one per cent up to 17%, and then three points reduction for each one per cent above 17%.

2. *Yield of malt.*

(a) Weight per bushel 2
Two points reduction for each pound below 55 pounds.

(b) Weight per 1,000 kernels 2
One point reduction for each gram the 1,000 kernels weigh less than 50 grams.

(c) Size of kernel 2
Allow 5 points for 7/64
Allow 10 points for 8/64
Allow 15 points for 9/64
Allow 20 points for 10/64
Allow 25 points for 11/64 or abov

(d) Thickness of hull. 2
Full points for 8% hull, three points reduction for each one per cent above 8.

(e) Loss in weight 30
Ten points reduction for each one per cent loss over 20%.

3. *Ease of malting.*
   - (a) Peeled kernels 25
     Two points reduction for each one per cent of peeled kernels.
   - (b) Broken kernels 25
     Five points reduction for each one per cent of broken kernels.
   - (c) Color 50
     Three points reduction for each per cent the color is below the standard.
   - (d) Sprouters 25
     Three points reduction for each per cent of sprouted kernels.
   - (e) Water absorption 50
     Full points for 100% water absorption, one point reduction for each one per cent less absorbed.
   - (f) Germination 300
     Reduction:
     1 point reduction for each 5% not germinated in 2 days.
     1 point reduction for each 1% not germinated in 3 days.
     2 point reduction for each 1% not germinated in 4 days.
     5 point reduction for each 1% not germinated in 5 days.
     10 point reduction for each 1% not germinated in 6 days.

4. *Quality of Malt.*
   - (a) Protein 100
     Ten points reduction for each per cent of protein above 8%.
   - (b) Mellowness 100
     Two points reduction for each per cent below 90%.
   - (c) Growth 100
     One point reduction for each per cent in ½—¾ and two points reduction for each per cent in 0—½.
   - (d) Total extract 500
     Five points reduction for each per cent below 90%.

Method of Determination

Extraneous Matter

Weigh 500 grams of barley, drop it through an air blast to remove dust, chaff, etc. Then put through a screen with 12/64″ apertures to remove straws and parts of unbroken spikes. After this it is shaken on a screen with 8/64″ apertures to remove small seeds, etc. Other grains and weed seeds which have not been removed by the above operations are picked out by hand. When completed the barley is weighed and calculated into percentage of clean grain.

Uniformity of Size

Five hundred grams of barley is poured on a series of 4 shaking screens, with 11/64″, 10/64″, 9/64″ and 8/64″ circular apertures respectively, and shaken for 5 minutes at 250 strokes per minute. The percentage of barley remaining on each screen is determined. The sum of the two screens giving the highest figure is expressive of uniformity, i.e. 11/64 plus 10/64 or 10/64 plus 9/64 or 9/64 plus 8/64.

Skimmings

One hundred grams of screened barley is poured into a beaker containing about ½ litre of distilled water. The barley is agitated with a stirring rod and the swimmers skimmed off. The number of swimmers of barley kernels multiplied by 1.7 and divided by 100 gives a result approximating the much slower determination by weight.

Moisture

The moisture is determined by grinding the barley and weighing out 2 grams on an analytical balance, placing it in moisture dishes and drying in a vacuum oven at 100°C. for 6 hours.

Weight per Measured Bushel

The weight per measured bushel is determined in the usual way, a on pint measure being used and the grain dropped 4 inches through a 1¼" aper ture, stroked with a round stroke and weighed on a Toledo balance. Tw determinations are made and if a variation greater than one quarter poun is noted, the test is repeated.

Weight per 1,000 kernels (11)

Five hundred kernels are counted at random and weighed on a Torsio balance. The sum of the four weighings divided by 2 is equal to a 1,000 berr weight. There should not be a greater difference than 0.5 grams betwee the highest and lowest weight of 1,000 berries. This is calculated then o a dry weight basis. The weight of barley, less the amount of moisture in a equivalent weight of barley (i.e. barley weight multiplied by moisture an divided by 100), is subtracted from the berry weight.

Size of Kernel

Five hundred grams of barley is placed on four shaking screens wit circular apertures 11/64 inches, 10/64 inches, 9/64 inches and 8/64 inche in diameter. These are shaken for five minutes at 250 strokes per minute The amount of barley on each screen is ascertained and the two screens retain ing the largest amount of barley are determined as in the uniformity o size test, the size of the aperture in the second screen being considere indicative of the size.

Thickness of Hull (11)

One hundred grams of barley is steeped in tap water for 24 hours a a temperature of 20°C. to 25°C. The husk is then peeled off by means o a sharp knife and is dried for 2 hours at 100°C. to 105°C. and calculate on a dry weight basis.

Loss in Weight Due to Malting

Five hundred grams of clean barley is weighed into a 5" x 6" zin cage. The barley is malted by steeping for 48 hours in water at 11°C. germ inated for 6 days at a temperature of 15°C. and dried for 48 hours—12 hour at 30°C., 12 hours at 50°C., 12 hours at 65°C., and 12 hours at 80°C. Th loss is calculated on the basis of dry barley.

Peeled and Broken Kernels

When the weight per 1,000 kernels is being taken the peeled and broke kernels are separated from the sound kernels and counted.

Colour

Colour is largely due to an excess of moisture during the ripening an harvest period, either in the form of rain or dew. Therefore this colou would be expected to be largely soluble in water. One hundred grams o grain is weighed into a 1 pint Gem sealer. This is revolved on a wheel at th rate of 28 revolutions per minute for 2 hours. The dust is then blown ou of the grain by means of a blast machine, 250 ml. of water is added to eac beaker and the grain is again put on the wheel for 2 hours. It is then filtere the first part of the filtrate being thrown back and the intensity of colou

determined by means of a Colorimeter. Due to some difficulty of obtaining an inorganic standard solution, barley free from any weathering is used as a standard. The colour is then determined on a percentage basis and reported as such. In addition to this a Munsell colour apparatus is used, similar to what is used for soils work. Special colours, however, have to be substituted and the barley placed also in a whirling disc. The actual colour of the barley is measured in percent of white, black, green, blue and yellow. From this it is possible to calculate a definite colour basis.

Sprouters

When the weight per 1,000 kernels is being determined the number of sprouters which show a distinct rootlet or acrospire are determined and reported on a percentage basis.

Water Absorption

Five hundred grams of barley is weighed into a malting cage and immersed in flowing water at a temperature of 11°C. At the end of 60 hours the barley is placed in a Centrifuge and the water all thrown off. It is then reweighed and the absorption calculated on a dry basis.

Germination

Under germination there are two things to consider: (1) Germination Capacity; (2), Germination Energy.

Germination Capacity is the total percentage of kernels that will germinate.

Germination Energy is the uniformity and power of growth.

The germination is obtained by weighing 500 grams of barley into a malting cage, steeping this for 60 hours at 11°C., centrifuging it dry and placing in a compartment with a relative humidity of 95, with a constant change of air at 15°C. Each day several lots of 100 kernels are selected at random and the germination noted. If there is much variation, as many as ten counts will be made on the barley. This is done each day for six days. The total germination is considered Germination Capacity and germination during the first three days is considered Germination Energy.

Protein

The protein is determined according to the modified Kjeldahl method. The factor used is 6.25, since this is the factor that is used most commonly in breweries and malt houses.

Mellowness

Two lots of 50 kernels of malt are cut longitudinally with a Kickelhayn tester and the kernels counted, classifying them into mellow, ¼ glassy, ½ glassy, ¾ glassy and all glassy. These values are then multiplied respectively by 100, 75, 50, 25 and 1. They are then divided by 100, which gives the percentage mellow.

Growth

One hundred kernels of male are examined and the length of the acrospire in relation to the length of kernel noted. They are classified into groups

with the acrospire having the following lengths in comparison to the length of the kernel: From 0—½; from ½—¾; and from ¾—1.

Extract in Malt

Fifty grams of the finely ground malt is doughed with 250 cc. distilled water at 47°C. (use beaker of about 600 cc. capacity) and held at 45°C. for 30 minutes, then raise temperature 1°C. per minute until 70°C. is reached. After 10 minutes at 70°C. add 125 c.c. water at 70°C. and keep the mash at this temperature for another 20 minutes (total time at 70°C. 30 minutes). Stir mash every 5 minutes during mashing. Cool mash to 20°C. and increase its net weight to 450 grams with water. Thoroughly mix and filter. The first 100 c.c. from the nitrate is poured back and the specific gravity at 17.5°C. taken on the second run. From the specific gravity the Balling is obtained from Ballings' table. If this table is not available the following formula may be used, (Sp. Gr.—1000.00) × .2484. Example: (10320—1000) × .2484 equals 7.95 Balling, then the

$$\frac{S \times (800 + H)}{100 - 8} = E \text{ and } \frac{E \times 100}{100 - H} = E \text{ dry basis.}$$

in which E equals Extract

H equals moisture in sample or 3.0 per cent.

and S equals Balling or 8.00

$$\text{Then } \frac{(800 + 3.0) \times 8.00}{100 - 3.0} = 69.83 \text{ Extract}$$

$$\text{And } \frac{69.83 \times 100}{100 - 3.0} = 71.99 \text{ per cent Extract dry basis.}$$

Application of Method

The suggested Canadian method has been tried out on several different series of barley in this laboratory. The following table illustrates how it works with varieties. A sample to be considered good malting barley should test 80 per cent or over.

Evaluation of Varieties of Barley for Malting M.A.C. 1927.

Proerties	Perfect Score	Trebi	O.A.C. No. 21	Hannchen	Duck-bill
Cost of Preparing Barley for Malting					
Extraneous matter	25	25	25	25	25
Uniformity of size	30	22.8	25.3	24.7	27.7
Skimmers	25	23.9	22.9	23.0	23.1
Moisture	20	16.1	16.1	15.7	16.1
Total	100	87.8	89.30	88.4	91.90
Percentage		87.8%	89.30%	88.4%	91.90%
Yield of Malt					
Weight per measured bushel	25	19.8	19.	22.4	21.6
Weight per 1,000 kernels	25	21.9	10.4	16.2	21.9
Size of kernel	25	15.0	15.0	15.0	20.0
Thickness of hull	25	17.9	18.0	23.5	23.2
Loss in weight	300	193.4	215.9	264.8	227.7
Total	400	268.0	278.3	341.9	314.4
Percentage		67.0%	69.6%	85.4%	78.6%

Ease of Malting					
Peeled kernels	50	49.6	50	30.6	49.5
Broken kernels	25	24.7	22.2	24.6	23.8
Color	50	45.0	45.0	45.0	45.0
Sprouters	25	25.0	25.0	25.0	25.0
Water absorption	50	28.49	30.6	41.1	34.54
Germination	300	91.60	273.1	00.0	259.8
Total	500	264.3	445.9	166.3	437.6
Percentage		52.8%	89.1%	33.2%	87.5%
Quality of Malt					
Protein	300	277.0	272.0	262.0	256.0
Mellowness	100	76.0	94.0	74.0	96.0
Growth	100	30.0	72.	8.0	94.0
Extract	500	399.1	409.3	429.6	420.0
Total	1000	782.1	847.2	773.6	866.0
Percentage		78.2%	84.7%	77.3%	86.6%
Recapitulation					
Cost	100	87.8	89.3	88.4	91.9
Yield	400	268.0	278.3	341.9	314.4
Ease	500	264.3	445.9	166.3	437.6
Quality	1000	782.1	847.2	773.6	866.0
Total	2000	1402.2	1660.7	1370.2	1709.9
Percentage		70.1%	83.0%	68.5%	85.4%

Conclusion

Before any investigation in regard to the value of barley for malting could be reported it was necessary to arrive at some basis for computing its value. A study of the methods in use in other countries indicates that there was no great uniformity and that the system varied with the different classes of barley. After experimenting for some time the above has been suggested as a means for carrying on this work. It was also essential that the value be computed on a single figure basis since a good deal of these data will have to be analyzed statistically.

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PLATE I.

Comparative degree of maturity in four varieties of barley.

Figure 1. O.A.C. 21
Figure 2. M.A.C. Duckbill.
Figure 3. Trebi.
Figure 4. Hannchen.

THE COMPARATIVE VALUE OF SCARIFIED AND UNSCARIFIED SWEET CLOVER SEED*

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In previous communications (*1*) (and Loc. cit.) this question has been considered from the point of view of the contribution of the individual seed towards the final stand. It was found that during the first growing season of the period under consideration (1927-8) the hard seeds had about 50 per cent of the value of the permeable seeds, but that when the whole period (up to late spring, 1928) was considered, the hard seeds were of approximately equal value. The plots, on the results of which these conclusions were based, were to some extent artificial in that the seeds were spaced very wide apart (6 inches in the row, rows 4 feet apart), and thus the element of competition did not enter; though in every other respect they were strictly under field conditions. In order to check up on these findings a number of yield plots were seeded and an investigation carried out along exactly the same lines as was done for alfalfa in a paper recently published (*2*).

The yield plots were seeded at the Dominion Irrigation Experiment Station at Brooks and at the Dominion Experimental Station at Lacombe.

It was intended to seed the same two samples at each place, one representing a scarified lot, and one an unscarified, but as there was only sufficient seed of the unscarified lot for use at both stations, two samples were secured to represent the scarified lot. Details of these samples are given in table 1.

Laboratory tests on these samples were made at the time the field plots were seeded, weak and broken sprouts of course, not being counted as having germinated.

Table 1. *Laboratory tests on samples used (1928).*

Sample	Where used	History	Germ.	Hard Seeds	Germ. as reported as basis for grading
A	Brooks	Scarified	93	5	98
B	Lacombe & Brooks	Unscarified	59	35	94
C	Lacombe	Scarified	93	6	99

Lacombe

Four 1/100 acre plots were seeded broadcast on June 28th, 1928 at the rate of 15 lbs. per acre, samples B and C each being seeded on two plots. Seeding was immediately followed by rain, providing ideal conditions for germination. When the plants were one to two inches high the average number of plants per square yard was determined for each sample with the following results:

C—Scarified 348 plants per sq. yd. (average)
B—Unscarified 287 plants per sq. yd. (average)

On the basis of a value for hard seeds of 50 per cent of that of the permeable, (as was previously reported for the first growing season), sample B may be

*Contribution from the Laboratory Division, Seed Branch, Dept .of Agriculture, Ottawa, Canada.
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rated at 59 plus 18=77 and sample C at 93 plus 3=96; i.e. B should have 80 per cent of the value of C. The above count shows B as having 82.5 per cent of the value of C, a result very close to the theoretical. However, when the yields from these plots are considered, as given in table 2, there is very little difference between the green weight obtained from the scarified and the unscarified seed plots; less than 3 per cent.

TABLE 2. *Yields from scarified and unscarified samples compared.*

Sample	Plot	Green weight per acre West Half	East Half	Avg.	Dry matter per cent	per acre
B Unscarified	I	9000	11800	11550	16.50	1906
	II	14200	11200			
C Scarified	I	12800	12600	11850	14.84	1759
	II	15400	6600			

In the last two columns of this table, the percentage of dry matter for the product of each sample and the dry matter yields calculated therefrom are given. It appears that in these plots the plants produced by the unscarified seed have a heavier dry matter content, thus giving a heavier total yield on a dry basis for this sample. This is not out of keeping with the thriftier growth observed for this sample as compared with the scarified in the Brooks plots reported in the next section.

BROOKS

Eight plots were seeded at this station on June 7th, 1928, at the rate of 6 lbs. per acre: four to sample A and four to sample B in alternate plots. Each plot consisted of 10 rows 25 feet long, the rows being 8 inches apart.

Abundant rainfall in June and July provided ideal conditions at the time of seeding and after, which with high temperature caused prompt germination; all plots came up quite evenly to the eye.

On August 3rd and again on August 22nd stand counts were made. For these, sections of a number of rows 36 inches long selected at random from each plot were taken and the plants in each such section counted.

The results obtained are given in table 3.

TABLE 3. *Plants per linear yard.*

Plot No.	Row:—* a	No. plants per linear yard b	c	d	e	Avg. per. yd. ea. plot	Avg. all plots
					(1)	Count August 3rd, 1928.	
A 1	42	39	52	52	36	44.2	
A 2	59	51	57			55.7	
A 3	43	44	45			44.0	
A 4	48	48	50			48.7	48.
B 1	49	64	56	51		55.0	
B 2	44	39	40	62	46	46.2	
B 3	43	38	61	47		47.3	
B 4	39	40	56	45		45.0	48.
					(2)	Count August 22nd, 1928.	
A 1	36	23	43	38	32	34.4	
A 2	48	45	44	46	52	47.0	
A 3	40	37	35	40	45	39.4	
A 4	38	53	43	53	52	47.8	42.
B 1	55	36	47	48	45	46.2	
B 2	59	44	32	44	33	42.4	
B 3	41	40	53	40	53	45.4	
B 4	37	30	61	58	43	45.8	45.

* Rows a, b, c, etc. refer to any rows selected at random.

On the whole, counts are seen to be rather more uniform on the scarified plots than on the unscarified. For this reason at the first count, which was more or less of a preliminary nature, rather more counts were made on the latter. From this table it will be seen that at the second count there is a slight advantage in favour of the unscarified (B) sample amounting to a little over 6 per cent, while at the first count there is practically no difference. During the growing season no marked difference in vigour was noticeable until about the second week in August after which the unscarified plots shot ahead and by the 20th of August were 4 to 6 inches higher than the scarified. This increased growth became very evident on comparison of the yields secured from the respective plots, which were cut on August 29th, 1928, and are shown in table 4. In each plot two rows were cut for perimeter and to facilitate harvesting.

TABLE 4. *Yields (green weight) from scarified and unscarified seed compared.*

Scarified		Unscarified	
Plot No.	Lbs. per acre	Plot No.	Lbs. per acre
A 1	16830	B 1	30720
A 2	17810	B 2	26635
A 3	8825	B 3	18465
A 4	8007	B 4	18630
Average:	12868		23613

The 3 and 4 plots of both A and B samples were separated from the 1 and 2 plots of both samples by an intervening plot, hence different soil conditions clearly account for the markedly lower yields in the 3 and 4 plots as compared with the others. Apart from that the results are quite consistent and show the unscarified sample as having out-yielded the scarified by 83.5 per cent.

Discussion

Under strictly competitive field conditions, where normal rates of seeding have been employed, the sample with a comparatively high percentage of hard seeds at Lacombe produced about 20 per cent fewer plants than the sample having only 6 per cent hard seeds. The number of plants produced however, did not influence the yield which was practically the same for the two samples. At Brooks, the number of plants produced by the two samples was approximately the same but the unscarified sample out-yielded the other by nearly two to one. While it should be borne in mind that the scarified samples used were different in the two localities, these results point to a more thrifty and vigorous growth on the part of the plants produced by unscarified seed. It should again be stressed, however, that the conditions at seeding time and subsequently were exceptionally favourable to prompt germination in both districts, and these results should be considered with much caution.

Summary

1. In order to supplement previously reported experiments, scarified and unscarified samples of sweet clover were compared when grown under strictly field conditions at normal rates of seeding.

2. Plots were seeded at two districts. In the one, the unscarified sample produced about 20 per cent fewer plants but showed no appreciable difference in yield; in the other, the unscarified sample produced approximately the same number of plants but out-yielded the other by 83.5 per cent.

3. Plants produced by the unscarified sample were more thrifty and vigorous.

4. Hardseededness in sweet clover, during the season under consideration which was exceptionally favourable to prompt germination, did not appear to be a limiting factor with respect to the stand secured.

Acknowledgment

The thanks of the author are due to the officials of the Dominion Experimental Station, Lacombe, and the Dominion Irrigation Experiment Station, Brooks, who did most of the field work reported in this paper.

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NOTES.

REVIEW OF THE WORK OF THE C.S.T.A. COMMITTEE ON GRADUATE STUDIES

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I have been asked by the President of the Society, Dr. E. S. Archibald, to prepare a brief review of the work of the Committee on Graduate Study. This Committee was first organized in 1921, under the Chairmanship of Dr. F. C. Harrison, who at the 1922 Convention outlined the basic principles of graduate work. These principles became the foundation on which the future activities of the Committee were based.

The second report of the Committee as presented by Dr. R. Newton in 1923, outlined facilities at that time available for graduate work in Canada, the method of direction of graduate work at different Universities, a discussion on the question of centralization, University credit for extramural research, and teaching schedule for instructors.

The third report of the Committee dealt with a number of general yet pertinent questions, such as the report of the Committee on Graduate Study of the Conference of Canadian Universities, authorized transference of work, summer courses in graduate work, fundamental problems in degree courses, etc.

The scope of the problem before the Committee was by that time fairly clearly defined, and as a result it was possible for the Committee to outline a definite programme (see *Scientific Agriculture,* July, 1925) which guided it in its future deliberations.

The report as presented by the Committee in 1925 dealt chiefly with the questions of extramural research, transference of work, leave of absence and salary arrangements. These questions were considered almost entirely from the standpoint of the employees of our Dominion and Provincial Departments of Agriculture who wished to proceed with advanced study, but who were restricted in their desire by the residence requirements of the Universities and by the regulations of the service in which they were employed. The study showed that there was a great willingness on the part of all concerned to meet the needs of those graduates in the employ of the Dominion and Provincial Departments of Agriculture who were desirous of taking post graduate work.

The activities of the Committee during the following year and as reported to the 1926 Convention were largely a study of three fundamental questions:

a. The relation between undergraduate and graduate courses with regard to division and sequence of work.
b. The nature and content of courses leading to the master's and doctorate degrees.
c. The general question as to what proportion of the graduate work might with advantage be taken in the natural science departments of our universities.

The concensus of opinion on these questions as expressed by the various Universities of Canada is given in the report of the Committee for 1926. As it was evident at that time that the Universities were extremely sympathetic in their attitude to any scheme whereby graduate work for students and workers in technical agriculture might be promoted, it was decided to submit a very definite recommendation to the effect that the Society proceed at once with the third part of the programme, which was a study of the collective resources of our Canadian Universities from the standpoint of graduate work in Agriculture. It was recommended that the Society should appoint one man to make this survey and that he should give his entire time to this project for a period of at least six months. These recommendations were approved by the Society, and have since been acted upon. Through the generous assistance of the International Education Board of the United States, the appointment of Dr. R. Newton of Edmonton to do this work was made possible. Dr. Newton is now engaged at this task, and his later reports and recommendations will undoubtedly contain much that will be of interest to the Society and materially assist in the establishment of adequate facilities for post-graduate work.

At the time of the 1926 meeting of the C.S.T.A. it seemed advisable that, until such time as effect had been given to the major recommendation of the Committee, the Committee on Graduate Study should be temporarily dissolved. A recommendation to that effect was made by the Committee and acted upon by the Society. This idea did not imply that the work of the Committee had been completed or that nothing further could be done by such a Committee. It was felt, however, that until the survey of our resources for graduate work had been made, there was little need for its immediate continuation. Now that this work is proceeding it may be advisable that a new Committee be formed which in the light of the findings of the survey would again take up the problem of assistance to the employees of our various Departments and institutions who wish to proceed with graduate work, but who are handicapped in their desire by the duties and regulations that govern their positions. Other problems, which it is unnecessary to enumerate also present themselves for consideration. Undoubtedly Dr. R. Newton, even though his survey may not be complete at that time, will have suggestions to place before the members of the Society at the June Convention. It would therefore seem advisable that the members of the Society again familiarize themselves with the past reports of the Committee, and be prepared to discuss the problem associated with the development of graduate work for students and technical workers in agriculture in Canada.

NOTE ON THE REARING OF *Trichogramma minutum* Riley

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[Received for publication April 4, 1929]

In the rearing of *Trichogramma minutum* Riley during the summer of 1928, several difficulties of major importance were encountered. There was a wide variation in the ratio of reproduction and a lack of certainty as to the number of eggs which should be presented for parasitism to a

given number of *Trichogramma*. The method used was as follows: the eggs parasitized by *Trichogramma* were kept in a bright light at a temperature of 83 degrees Fahrenheit, and at this temperature emergence commenced in about eight and one half days and continued for from twelve to thirty-six hours. When emergence was well started a card bearing fresh eggs of *Sitotroga cerealella* Ol. was placed in the petri dish with the *Trichogramma*. At the end of twelve hours this egg-card was replaced by a fresh one and the change was repeated at twelve hour intervals as long as there was an appreciable number of *Trichogramma* present. Sometimes the heaviest parasitism was secured on the first card and sometimes on subsequent cards. This resulted in a loss of host eggs when the parasitism was poor, and a loss of parasitisms when the parasitism was better than anticipated.

It was felt that if emergence could be spread over a shorter period of time these difficulties would be obviated. As the result of a series of experiments it has been found that if the eggs, after being parasitized, are kept in a dark portion of the incubator very few of the parasites will have emerged at the end of the period required for total emergence under the previous method of handling. If placed in strong light at this time there is very rapid and complete emergence with mating taking place immediately. Under these conditions if one card bearing an abundant supply of host eggs is placed in the cage a greater number of parasitisms is secured than had been secured on all the cards by the old method. Practically all the *Trichogramma* are dead in twenty-four hours and no further cards are required. The ratios of reproduction secured by this method have never been below six to one and have been as high as eleven to one. All changing of cards is done away with and due to better mating secured, when all the parasites emerge in a short period, there is a marked increase in the proportion of females. It is felt that when liberations are to be made in test plots at fixed times it will be of distinct advantage to be able to have all the *Trichogramma* emerge when wanted.

LABORATORY REARING OF *Laspeyresia molesta* Busck

W. Elgin Steenburgh
Dominion Entomological Laboratory, Chatham, Ont.

[Received for publication April 4, 1929]

The laboratory rearing of the Oriental Peach Moth (*Laspeyresia molesta* Busck) was undertaken to determine a satisfactory method of propagating this insect under artificial conditions. The object of the work is to ensure a constant and plentiful supply of larvae for use in the rearing of its endophagous parasites. The experiments were carried out in specially constructed incubators which remained at a temperature of 80 to 85 degrees F. Humidity proved an important factor and was varied with the different stages of the insect.

The initial larvae were collected from infested peaches and quince in the Niagara district in the fall of 1928 and placed in cold storage temperature of 33 degrees F. The first larvae used were removed after three weeks, allowed to warm slowly, and were then placed in an incubator.

Others were removed, as needed, over a period of three months. Emergence began on the tenth day and continued over an extended period. The peak of emergence was reached between the 14th and 21st days. The percentage of emergence secured from the different lots of larvae varied directly with the time the larvae remained in cold storage. The first larvae showed an emergence of 41 per cent while the larvae used three months later gave an emergence of 71 per cent.

The emerging moths were used in egg laying experiments. Oviposition cages which gave good results in the insectary proved unsatisfactory for winter laboratory breeding when peach leaves, which are necessary to incite oviposition, cannot be secured. The type of cage found most satisfactory is a modification of Briand's corn borer oviposition cage (Can. Ent. Vol. LXI, No. 3. p. 53) and consists of a cylinder 5 inches in diameter and 12 inches long lined with a heavy grade of waxed paper. Approximately 100 females, with an equal number of males, are confined in this cage as it seems necessary to produce a crowding of the insects to secure oviposition. The moths live longer when a high humidity is maintained in the oviposition cage. This is secured by the use of cotton moisture pads which are saturated daily. More eggs are secured per female when sliced apple is kept in the cage. The moths feed on the pulp and oviposit on the peel. The females distribute the eggs quite evenly between the epidermis of the apple and the waxed paper. During the day the moths are exposed to the light, but are covered at night. The females oviposit in the darkened cage.

Each day the sheet of waxed paper is removed and small pieces of paper, containing the adhering eggs, are cut from the larger sheet. These eggs are kept in a moist atmosphere to prevent dessication and just before hatching are placed on apples. Twelve eggs are found to be a suitable number for an apple of average size. Due to the rapid growth of fungi in the warm moist atmosphere of this incubator it was found necessary to keep the apples in another incubator where a much lower humidity is maintained. A good circulation of air through the apples is also important and this is accomplished by placing the apples in metal trays with a top and bottom of 40 mesh wire screening. On reaching maturity the larvae leave the fruit and wander about searching for a place in which to spin their cocoons. They will not spin up on the smooth surfaces of the metal tray and very readily crawl into the openings of corrugated cardboard placed around the inner surfaces of the tray just below the attachment of the top. This cardboard ring consists of strips, three- eighths inch wide by four inches long, held in place by small brackets soldered to the inside of the tray. These strips containing spun-up larvae are removed every seven days and are placed either in storage or in emergence cages as desired.

The results secured from the laboratory bred material are very gratifying. The moths live longer and are more active and the pre-oviposition period is considerably shorter. The females also laid more eggs than did those from the collected material and the resulting larvae produced a much higher percentage of healthy moths. At present the work is being carried on entirely with material reared in the laboratory and is progressing in a very satisfactory manner.

SOME PIG BREEDING OBSERVATIONS

J. W. G. MacEwan†
University of Saskatchewan, Saskatoon, Sask.

[Received for publication April 23, 1929]

An analysis of the pig breeding records at the University of Saskatchewan over a period of years (1921—1928 inclusive) reveals quite a few matters of general interest to pig breeders. The period of gestation in pigs has been placed by a number of authorities at 112 days, and the majority of breeding charts appear to have been made out on the 112 day basis. It would appear from data available, however, that the mean gestation period in sows is appreciably longer than that stated. It was found, further, that the period of gestation varies to some extent with breeds, and to a still lesser extent with the season of the year.

Size of litter and age of sow do not seem to be factors that materially influence the length of pregnancy. There was, however, an average difference of more than a day between the spring and the fall litters in the Yorkshire breed. The spring litters were carried for the longer period. In all, the records of 316 farrowings were studied, representing the Yorkshire, Tamworth and Berkshire breeds, and the following will show the relative periods of pregnancy and the number of some of each breed studied for spring litters:

	No of Sows	Mean Gestation	
Yorkshire	190	114.94 days	± .084
Tamworth	73	113.84 "	± .147
Berkshire	30	116.13 "	± .159

The average for all breeds was 114.93 days and it would therefore mean that breeders might better accept 114 or 115 days as the normal if there is a normal period.

It was early pointed out by Darwin that the earlier maturing breeds of sheep carried their lambs a shorter length of time than the slower maturing types, of which the Merino is a representative. It has been observed, too, that earlier maturing breeds and strains of horses are shorter in their gestation than late maturing breeds. That being the case, one might expect to find the bacon breeds a little later in giving birth to their young. The question consequently arose as to whether or not cross-bred pigs, which many breeders claim come to maturity earlier than straight bred pigs, are not carried a shorter time by their dams. In order to determine to what extent such might be true, the cross-bred litters were compared with in-bred litters of the last few years. It is recognized genetically that cross-breeding is quite in contrast to in-breeding in its effects. Unfortunately only a limited number of matings were available for this study and the results were as follows:

No. of litters	Breeding	Mean Days Gestation
8	Brother-sister matings Yorkshires	116.00
20	York boar × Tamworth sow	114.10
38	Cross-breds (all crosses)	114.28

The difference between the gestation of Yorkshire and Tamworth pigs, as pointed out, was found to be 1.10 days. The difference between in-bred

†Assistant Professor of Animal Husbandry.

Yorkshires and cross-bred Yorkshire-Tamworths with a Tamworth dam was 1.90 days. This difference between 1.10 and 1.90 days would suggest at least that the cross-bred pigs came to fetal maturity a little earlier than the in-bred pigs.

The question of size of litters presents an interesting field. It is generally recognized that the Yorkshire breed is one of, if not the most, prolific breeds and that the bacon breeds as a whole are more prolific than the lard breeds. It is true that the American breeds have been improved in point of prolificacy in recent years. The three breeds compared as follows for spring litters:

Breed	No. studied	Mean Size of litter	
Yorkshire	190	10.55	± .143
Tamworth	73	8.84	± .231
Berkshire	30	8.16	± .285
Total	293	9.87	

Fall litters seem to be a little bigger than spring litters. That idea is not new at all, although actual data seem to be lacking. In this survey 23 Yorkshire fall litters averaged 10.82 pigs per litter, and 190 Yorkshire spring litters averaged 10.53 pigs per litter. The difference is not great but seems fairly significant. The reason for such a variation is explainable in much the same way that the advantage of flushing ewes is explained. Sows are bred for their fall litters at a time of the year when they are on pasture and usually thriving to a greater extent than the sows that are bred in early winter for spring farrowings. It seems likely that sows gaining in condition will, like ewes gaining in condition, ovulate more eggs and, granting fertilization, conceive a larger number of embryos.

Work carried on by Wisconsin authorities would indicate that many pigs die during fetal life and are completely absorbed before the litter is farrowed. The causes are not particularly obvious but crowding, lack of nutritional material, and lethal factors which may be much more common than we suppose, are suggested. They examined 3.967 fetuses and found that 146, or 3.68 per cent. were undergoing degeneration in some stage. It is possible that these factors are more largely responsible for small litters than we have supposed.

The question of mortality at birth was considered. It is exceedingly difficult to analyse the mortalities that occur after birth on account of the multiplicity of factors that are concerned, many of which are purely environmental. In the Yorkshire breed, the breed which offered the best opportunity for study, the birth mortality was found to be materially lower among fall born litters than spring litters. In the former the mortality at birth was 2.4 per cent and in spring litters over the period of years, 4.4 per cent of the pigs were born dead. For all Yorkshires the average mortality at birth was found to be 4.22 per cent.

The variation in birth mortality in breeds was found as follows:

Yorkshires	-	4.40 per cent
Tamworths	-	7.58 " "
Berkshires	-	5.71 " "

These figures are for spring farrowings.

It was not found that the percentage birth mortality was any greater in big litters than in small. There were, as might be expected, more dead pigs per litter in the large litters, but the percentage of dead births was not appreciably different in either.

Birth mortality was a little lower in cross-bred litters. Thirty spring farrowed cross-bred litters, whose parents were representatives of the above breeds, had a mortality at birth of 4.16 per cent. When all crosses were considered, including crosses with lard bred hogs, the percentage mortality was considerably higher.

The eight in-bred litters that were available for study showed a high birth mortality. Of the eight litters, six were full brother-sister matings and two were half brother-sister matings. All were pure bred Yorkshires. Sixty-two pigs were farrowed from these matings, of which 13 were born dead. This gives a 20.96 per cent mortality. This figure seems to contrast quite clearly with the lower mortality that occurred among the cross-bred pigs. This would point to a confirmation of the opinion that cross-bred pigs have added vigor before birth, as they no doubt have after birth, and that in-bred pigs are low in vigor before birth.

BOOK REVIEWS

CANADIAN AGRICULTURE FOR HIGH SCHOOLS. (The Macmillan Co. of Canada, Toronto, Ont.)

Many even outside of the high schools will be interested in this new production—presumably by Canadian authors. One cannot but wonder why the identity of its author or authors has been withheld. The fact that it is authorized by the Department of Education for Alberta suggests that it may have been produced at the instance of that department and that for some reason they wished it to remain anonymous. This is something of a disappointment as many people, including the membership of the C.S.T.A., would like to know who has (or have) produced such a welcome addition to the rapidly growing list of text-books for Canadian schools. We have no quarrel with the title although we cannot but suggest that "Agricultural for Canadian High Schools" would have been more easily justified. Possibly the fairest criticism that one could make of the contents of the book is that it contains far too little information for the young Canadian student relative to Canadian agriculture. Probably 95 per cent of the matter contained in the book would be just as applicable in American as in Canadian high schools. But it is a Canadian production and one which Canadian teachers and agriculturists will gladly accept at its full face value.

From the standpoint of the teacher of agriculture in Canadian high schools the book has one outstanding point of merit—it provides a very satisfactory biological approach. It recognizes that agriculture, in order to be educational at all, must be treated as applied biology, chemistry, physics, and mechanics. Possibly the applications are not as closely drawn as they might be at times; in fact it is apparent that the enthusiasm of the author for natural history has drawn him rather too far from the main agricultural highway, in the pursuit of birds and butterflies, into inviting glades and by-paths. Some valuable pages have thus been taken that really were badly needed for the main purposes of the textbook.

In the light of the requirements of modern science texts the book is noticeably deficient in the number of its illustrations with the exception of the sections dealing with weeds and live-stock. Many of the illustrations are larger than they need be, resulting in a needless waste of very valuable space.

Reference to sources of additional information, such as any busy teacher or student would welcome, is almost entirely lacking and the omission of an index in a book of nearly five hundred pages, covering as it does a very large number of topics, is well-nigh unpardonable.

It is not easy to maintain a balance in the treatment of the several major divisions of a general textbook on agriculture and especially is this true if the book is the product of more than one author. In the book under review it would seem that, even for Alberta, field crops and horticulture have suffered somewhat and the humble but obiquitous potato seems to have been entirely overlooked. One also wonders whether the section on

soil study which is well handled might not have been introduced earlier in the book. That, however, can be adjusted by the teacher, ad libitum. The sections on agricultural botany, insect life, soils, bacteria and animal husbandry are as fully treated as one could expect to find them in a general textbooks; as for the rest of the topics, they may claim their rightful place when a new edition of the book is brought out. Even as it is "Canadian Agriculture for High Schools" will be well received throughout the Dominion.

J. W. G.

MINERALS IN PASTURES AND THEIR RELATION TO ANIMAL NUTRITION. J. B. Orr. Rowett Research Institute, Aberdeen. (H. K. Lewis and Co. Ltd. London, 1929. 10/6 net.)

"It is well known that, apart from bulk, the feeding value of pasture varies in different areas, and it has been shown in recent investigations that one of the important factors in determining the feeding value is the amount of calcium, phosphorus and other minerals present. Some pastures, indeed, are so poor in one or another of these elements that the deficiency is the cause of disease in grazing animals."

The above paragraph, which appears in the preface, puts into a brief statement the reasons for the survey of the literature on the subject of minerals in pastures recently completed by a Sub-committee of the British Civil Research Committee, and summarized in book form by one of their number, Dr. J. B. Orr, Director of the Rowett Research Institute, Aberdeen.

The wealth of material uncovered has been arranged under such headings as, "The Mineral Content of Pastures", "Factors Affecting the Mineral Content of Pastures", "Conditions under which Diseases due to Deficiency of Minerals in Pastures Occur", Chapters on "Deficiency Diseases in Grazing Animals" in Europe, Africa, Australasia, America and Asia, and "Effect of Mineral Intake on Rate of Production of Grazing Animals".

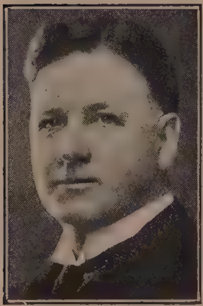
From the evidence collected it is clear that, while only in certain areas of the world is the deficiency of one or another of the mineral elements in pasturage so extreme as to cause symptoms sufficiently acute to be classed as diseases, there are wide areas over which a general poverty of mineral elements exists sufficient to affect the feeding value of the pasture. In these areas, the rate of growth of young animals is slow, the milk yield of cows poor, and the fertility of females low, as compared to "normal areas".

Corrective methods, both practical and experimental, practised in affected regions, are reviewed and the results obtained noted.

A complete bibliography of references appears at the end of each of the eleven chapters, and at the end of the book is found an alphabetical index of the authors cited. The book, therefore, quite aside from its value as an exhaustive and carefully arranged summary of the present information on the subject of minerals in pastures, becomes of especial value to workers and students in the field of mineral nutrition having need for a key to the literature on this subject.

E.W.C.

George Christie Creelman



Dr. G. C. Creelman died peacefully and suddenly in hi sleep, at his home in Beamsville, Ont., early on the morn ing of April 18th. He would have celebrated his sixtiet birthday on May 9th.

A terse newspaper announcement informed the read ing public that he had been Superintendent of Farmer Institutes in Ontario from 1898 until 1904, President o the Ontario Agricultural College from 1904 until 192(Agent General for Ontario in Great Britain from 192 until 1921 and that since then, on account of ill healtl he had been living at Beamsville, retired from public service.

The real merits of the man, the vastness of the work he did during hi lifetime, his wonderful personality and his devotion to agriculture, were full appreciated only by those who knew him. To them the news came as a blow– George Creelman is dead! Hundreds of graduates of the Ontario Agricu tural College, hundreds of practical farmers who had learned to respect hi knowledge, his ability as a speaker and his sympathetic understanding of thei problems and hundreds of personal friends who knew him as "George" c "G.C.", were stunned by the news.

For George Creelman was a great man. The fact that we knew him a a friend will make us happy; we shall remember his wit, his knowledge c men, his quick and wise judgment. And the realization that he is gone wi make us sad.

Of the C.S.T.A. George Creelman was a loyal supporter. He was electe a Fellow of the Society at the close of his term of office as President in Jun 1927. His expressed faith in the organization did much to give it stabilit and to increase its membership. Few members realize all that he did for the Society.

It is comforting to know that he was bright and happy the evening befor he died. Let us remember him as a genial man, a real "mixer,', a perfe host and a staunch friend. Let us recall his laugh during a game of bridg or on the bowling green, his quick recognition of old faces and his intima knowledge of the doings of O.A.C. boys. He would wish to be so remembere

To Mrs. Creelman and to his family, every member of the C.S.T.A.– English and French and from Atlantic to Pacific—extends sincerest sympath We knew him and we loved him.

CONCERNING THE C.S.T.A.

Notes and News

S. S. Phillips (British Columbia '23) has been appointed District Agriculturist at Smithers, B.C.

F. X. Gosselin (Laval '23) is Assistant County Agriculturist in Abitibi County West, P.Q. His address is Macamic.

Stanley Wood (Toronto '23) has been appointed Assistant Live Stock Superintendent under the Provincial Department of Agriculture, with headquarters at Fredericton, N.B.

A. F. Barss (Cornell '12) is pursuing studies towards a Ph.D. degree in the Department of Botany at the University of Chicago.

A T. Elders (Manitoba '24) formerly Assistant Agrostologist at the Dominion Experimental Farm, Brandon, Man., has received the appointment of Assistant Professor of Agronomy at the Manitoba Agricultural College, Winnipeg, Man.

J. P. Ficht (Alberta '24) is now Land Settlement Representative for the Colonization Branch of the Canadian National Railways with headquarters at Edmonton, Alta.

Philippe Granger (Montreal '28) has been appointed Assistant County Agriculturist in Argenteuil County. His mailing address is Lachute, P.Q.

Hector Beliveau (Laval '26) has joined the staff of the Field Husbandry Branch, Department of Agriculture, Quebec, P.Q.

L. C. Young (Toronto '27) has been appointed Assistant Superintendent at the Dominion Experimental Station, Fredericton, N.B. He takes over his new duties on May 1st.

J. R. Ostler (Toronto '24) has received the appointment of Agricultural Representative for Leeds County with headquarters at Athens, Ont.

W. T. G. Wiener (Manitoba '15), Secretary, Canadian Seed Growers' Association, and J. E. D. Whitmore (Toronto '26), Assistant to Mr. Wiener, are now permanently located at the headquarters of the C.S.T.A. in Ottawa.

George E. Sanders (Toronto '07) who is Entomologist with the Insecticide Division of the Ansbacher Corporation, has changed his address to 50 Union Square, New York City, U.S.A.

Trueman Stevenson (Saskatchewan '23) has joined the staff of the Dominion Seed Branch with headquarters at Saskatoon, Sask.

W. H. Mather (Saskatchewan '26) has been appointed Agricultural Editor of the Saskatoon *Star-Phoenix*.

E. A. Hardy (Iowa '17), Professor of Agricultural Engineering at the University of Saskatchewan, is at present on a tour of the United States visiting manufacturing plants for farm machinery.

G. Geizler (North Dakota '28) who has been Assistant Cerealist at the University of Saskatchewan for the past year is now Loan Inspector with the North American Life Assurance Company at Saskatoon, Sask.

J. L. Doughty (Alberta '21) has changed his address to Nevis, Alberta.

John Bernard Hoodless (O.A.C. '05) died suddenly at Guelph on Mon-day, April 15th, in his 44th year. He was with the Department of Agricul-tural Economics at the Ontario Agricultural College from 1921 until 192 and for the past five months has been Secretary of the St. Williams Planta-tions Ltd., and Windham Plantations Ltd. (tobacco producers), with head-quarters at Guelph, Ont.

We regret to announce that Professor H. M. Nagant has found i necessary, on account of ill health, to resign the position of French Secretar and Editor of the C.S.T.A., which he has held for the past four years. Al members will wish Professor Nagant a complete and speedy recovery.

No French material appears in this issue, but the matter of appointing successor for Professor Nagant will be considered immediately.

Applications for Membership

The following applications for regular membership have been receive since April 1, 1929:—

Baker, A. D. (McGill, 1923 B.S.A.), 1925 M.Sc.) Macdonald College, P.Q
Cameron, John (Saskatchewan, 1918, B.S.A.) Regina, Sask.
Collins, G. P. (Toronto, 1928, B.S.A.) Kemptville, Ont.
Evans, O. R. (Toronto, 1925, B.S.A.) Montreal, P.Q.
Ferguson, J. G. (Toronto, 1928, B.S.A.) Montreal, P.Q.
Goldie, J. A. (McGill, 1925, B.S.A.) Vineland, Ont.
Graham, T. O. (Toronto, 1928, B.S.A.) Morden, Man.
Grindley, T. W. (Alberta, 1923 B.A., 1925 B.Sc.; Minnesota, 1927 M.A.) Ottawa, Ont.
Jackson, L. D. (McMaster, 1909, B.A.) Hamilton, Ont.
Lavoie, E. (Laval, 1923, B.S.A.), Rimouski, P.Q.
Major, J. O. A. (Montreal, 1910, D.V.M.) Amos, P.Q.
Murphy, L. A. (British Columbia, 1925, B.S.A.) New Westminster, B.C.
Paquette, J. A. (Laval, 1914, B.S.A.) La Ferme, P.Q.
Pidruchney, W. N. (Manitoba, 1926, B.S.A.) Vegreville, Alta.
Scollie, H. M. (Toronto, 1928, B.S.A.) Guelph, Ont.
Timmermans, W. (Montreal, 1927, B.S.A.) Amos, P.Q.
Upton, H. E., Agassiz, B.C.
Wilson, H. E. (Saskatchewan, 1923, B.S.A.) Lacombe, Alta.
Wishart, G. (Toronto, 1924, B.S.A.) Chatham, Ont.

C.S.T.A. Officers, 1929-30

Just as we go to press, the results of the election of officers, conducte by mail ballot during the month of April, can be announced. They are a follows:

President: J. P. Sackville.

Vice-presidents: W. T. Macoun and Geo. Bouchard.

Honorary-Secretary: L. H. Newman (re-elected).

The ballots were opened on April 30th. 748 members voted.

The new officers assume their duties at the close of the Winnipeg con-vention.

Members of the Society, who are contemplating a trip to Great Britain this summer, should communicate with Mr. B. Leslie Emslie, Canadian Industries Ltd., Canada Cement Company Building, Montreal. Mr. Emslie, who is a life member of the C.S.T.A., has received the following communication from the Agricultural Research and Advisory Department of Nitram Limited., 28-30 Grosvenor Gardens, London, S.W.I., England:—

"We shall be greatly obliged if you will arrange to notify us whenever you hear that agricultural officials from Canada are paying a visit to this country, so that we can arrange to meet them in London. You might point out that our Research and Experimental Station at Jeallott's Hill, near to Maidenhead, is within easy reach of London and we shall be pleased to arrange for them to visit the Research Station, where they will receive a cordial welcome."

The Civil Service Commission at Ottawa is advertising the following vacancies in the Dominion Department of Agriculture. Applications should be addressed to the Secretary of the Commission.

Senior Live Stock Promoter. Initial salary $2,040.00 per annum, with increases of $120.00 per annum up to a maximum salary of $2,520.00. To be located in New Brunswick.

Dairy Produce Grader. Initial Salary of $2,520.00 per annum, with increases of $120.00 per annum up to a maximum salary of $2,760.00. To be located in the Maritime provinces.

Animal Husbandman (Bilingual). Initial salary of $2,040.00 per annum, with increases of $120.00 per annum up to a maximum salary of $2,520.00. To be located at Ottawa, Ont.

Experimental Farm Assistant (Grade 2). Initial salary of $1,620.00 per annum, with increases of $60.00 per annum up to a maximum salary of $1,920.00. To be located at Rosthern, Sask.

C.S.T.A. Provided with Headquarters

During the course of its development since 1920, the C.S.T.A. has had to face many difficulties and overcome many obstacles. Probably the most serious of these has been the need for adequate headquarters. For nearly five years the work of the Society was done either in the home of the General Secretary or in a small space provided in the printing establishment which produced the Society's journal. For the past four years a single room in an old building, inconveniently located, has been used.

The results of this condition are obvious. It is extremely difficult to do efficient work in suroundings which are congested and unsatisfactory in many ways. Few members of the Society knew where their headquarters (sic) were located and yet they felt that an organization of national scope should have suitable offices.

Until the latter part of 1928 no solution of this difficulty appeared possible. To provide adequate headquarters involved an expenditure far beyond the resources of the Society, and an assessment upon the members, who as a class were far from being highly paid, would have been futile.

In October, 1928, the General Secretary discussed the situation with Mr. Thomas Bradshaw, Vice-president and General Manager of the Massey-Harris Company. Mr. Bradshaw was extremely sympathetic. He saw the

need for adequate executive offices, in order that the important work of the Society might be performed with greater efficiency. But his conception of C.S.T.A. headquarters was more comprehensive. In his opinion, a national organization devoted to the advancement of agricultural education, research and experimentation, should have more than executive offices. It should provide its members with facilities for meeting together, for making appointments at Ottawa, etc. In other words, any member of the Society, coming to Ottawa, should feel that at the C.S.T.A. headquarters he would find a place, suitably furnished where he could meet his co-workers, where he could do his reading, writing and telephoning, and where any meetings he was to attend, would probably be held.

At the suggestion of Mr. Bradshaw the matter was left in his hands. During the winter he corresponded with a number of agricultural implement manufacturers and milling companies in an effort to raise a sum of money sufficient to meet the expense involved. The expense was prompt and generous, and the new headquarters are now available. They are located in the new Victoria Building on Wellington St., Ottawa, facing the Parliament Buildings, and consist of the following:

(1) Executive offices—300 square feet.
(2) Lounge room—400 square feet.
(3) Board room—200 square feet.

It is intended that the Board room will be used for any agricultural committee or executive meetings, requiring an attendance of not more than twenty persons. This room connects, by folding doors, with the lounge room, and the two rooms combined will provide seating accommodation for sixty people, the board room table automatically becoming the head table at these larger gatherings.

The headquarters are furnished throughout in a suitable manner and every member of the Society will appreciate the interest which has been taken in their organization by a group of commercial firms. The expenses for rental are fully covered for a period of five years and the total cost of equipment and furniture is fully covered in the gift.

The following six companies have promised to contribute $250.00 annually for five years for rent, and $250.00 for furnishings:

International Harvester Company.
J. I. Case Threshing Machine Company.
Deere and Company.
Massey-Harris Company.
International Milling Company.
Western Canada Flour Mills Company.

The Lake of the Woods Milling Company has contributed $250.00 for furnishings and $250.00 for rental for one year, but desires to consider the matter of further contributions from year to year.

The Ogilvie Flour Mills Company has contributed $250.00 for furnishings.

It should be added that the mailing address of the Society will continue to be, as formerly, P. O. Box 625, Ottawa, Ont. This ensures more prompt delivery of mail, which is of considerable importance in the case of matters dealing with the publication of the official journal.